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Feature Extraction Using Hexagonal Pixel and Scale Invariant Feature Transform in Ornamental Letter Recognition

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Abstract: *Ornamental letters can be defined as letter characters that are decorated through the addition of symbolic ornaments that might affect the meaning of the word. The accuracy of the recognition of ornamental letters generally decreased due to various things, such as unrecognized type of letters due to lack of detected keypoints, keypoint's position errors on the remaining letter ornament, different letter character forms from the data and the letter that is distorted by scale and rotation. The problem can be solved using Scale Invariant Feature Transform (SIFT) method combined with Hexagonal Pixel. SIFT method can produce features that are not affected by scale, translation, or rotation changes in objects. While the Hexagonal Pixel method is performed by changing the shape of pixels from square to hexagonal. The combination of SIFT and Hexagonal Pixel method proved that the number of keypoints increased by 50%, and the accuracy increased by 10%, comparing to the results using the SIFT basic method.*

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I. Introduction

Today, preservation of cultural assets is an important element of each country for storing knowledge and literature for future generations. One form of preserved cultural assets is an ancient document. Many typographic histories, ancient and historic documents generally have elements of drawings / ornaments, though they actually present the text. The ancient documents will be damaged due to the length of storage time,hence, some writing is not identified. In the ancient document, ornamental letters can be categorized as one element.

Ornamental letters can be used to start a new discussion or to illustrate the contents of each chapter in an ancient document. Ornamental letters are the letter used for decorating purposes in the form of special designs on each component of the letter, and by incorporating elements of images of objects, animals, or other ornaments on the design. To recognize ornamental letters in ancient documents, the form of pattern recognition in the form of letter recognition systems can be used. This system will be indispensable to assist in the business of digitizing information and knowledge, for example in the manufacture of digital library collections as well as ancient digital literary collections [1]. The letter recognition system for ornamental letters uses methods such as Local Dissimilarity Maps [2], Zipf Law [3], Deep learning [4], and the Aujol and Chambolle algorithms [5].

From the system of identification letters, there's the problem of the presence of the remaining ornaments that are recognized as the letters, as well as the types of letters that are not recognized due to the different forms of data and distorted by the scale and rotation. To overcome these problems, this research will be used a Scale Invariant Feature Transform (SIFT) method. This method is considered to have good effectiveness in the field of image matching [6], as well as high accuracy [7] [8].

However, the use of the SIFT method still creates problems in the introduction of letters with many ornaments. The problem is the decreasing of the recognition result due to the position of the keypoint on the rest of the ornament and only fewkeypoints are detected.

Among the various ways to overcome the lack of keypoint numbers, the hexagonal pixel method can be used. The hexagonal pixel method is able to change the shape of pixels from square to hexagonal as it can be proven to give better results [9]. In addition, this method is also capable of reducing the number of pixels required to display images with less storage space, and achieving accuracy [10]. This technique is also often used on face recognition [11] [12].

II. Material And Methods

This research using 100 data of ornamental letters. The data contain 26 random alphabet with the size of 300 x 300 pixel. This research method explains about preprocessing data of the letters and removal of ornaments / decoration, convolution of square pixel into hexagonal pixel, feature extraction of Scale Invariant Feature Transform (SIFT) algorithm, and recognition letter.

Preprocessing in this research is performed by several steps such as erosion to remove ornaments around the letter, median filter removes ornaments with different pixel value with its neighbors value, hence, most of the remaining ornaments can be erased, and binary to change the color of the image into binary form, which is black and white. Unprepared initial image data form can be seen in Figure 1.

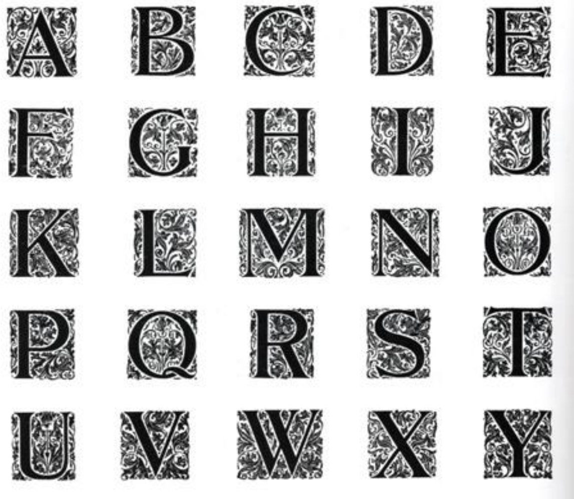
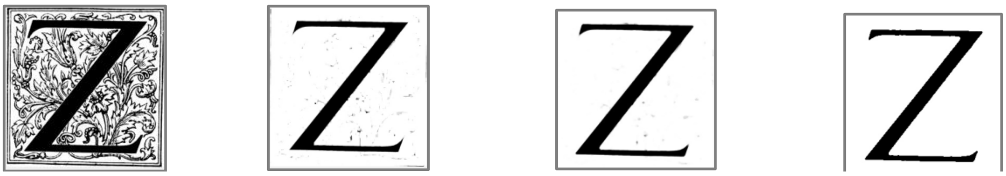


Fig 1. The ornamental letters

Fig. 1 shows the original image of ornamental letters obtained from various sources on the internet. Original image used in the form of images 26 characters alphabetical capital letter with the surrounding ornaments. The amount of data used is 100 images. The total number is more of the letters M, I, N, and W. The three sample capital letters are numbered more because of its similar shape. While the first letter is chosen because it only consists of a line, so the possibility of the letter can be recognized as another letter.Before entering the preproessing stage, the first step is to set brightness and contrast to get a balanced color. Next, the image cut to 300x300 pixel size and the image format is converted to JPG.This image will be preprocessed as follows.



(a) (b) (c) (d)

Fig 2.(a) The ornamental letters, (b) after erosion, (c) after median filter, (d) after binary.

Fig. 2 shows one of the original images of ornamental letters. This original image undergoes a preprocessing process of erosion to remove ornaments (b), followed by a median filter process to remove the remaining noise (c), and binary (c) to create 1 (black), and 0 (white) image pixels for convenience the next process.

Procedure methodology

In hexagonal imagery, the pixels will be more dense, making the surface sharp and comparable to others. It is very helpful to get information to process visual input and also simulation when visual process on image data

At this stage, square pixels (square pixels) will be converted to hexagonal image form. Each alternative pixel row is either left or right divided by half of its width. The change makes the pattern resemble a brick arrangement.Conversion of square pixels *S (p, q)* with *pxq* pixels and conformity with square will be converted to hexagonal.

The next process begins by finding the keypoint on the image by filtering it on a different scale. This will permit detection of the location of invariant keypoint [14]. The main thing used is the Gaussian function *G (x, y, α).*

To mark the highest peak of the Gaussian scale, the hexagonal image is processed so that features and edges can be marked. The formulation also eliminates the noise picture present in image through regular blurring. The advantage of the hexagonal process is the ability to sharpen edges, which are not biased in square pixels. The area will be automatically deleted if the convolution is applied to square pixels.

To mark the image feature, the substraction on the Gaussian scale sequence shown, is called the Difference of Gaussian (DOG) image with a factor k.When the DoG image is formed, pixels containing maximum intensity and x_i are the keypoint candidates of each DoG. Scale Invariant Feature Transform (SIFT) is an algorithm in computer vision to detect and describe local features (keypoint) in an image. In this method, an image will be converted into a local feature vector which is then used as an approach in detecting objects. SIFT has strong resistance to scale, rotation, and change of image angle

In this method, an image will be converted into a local feature vector which is then used as an approach in detecting objects. The SIFT has strong resistance to scale, rotation, and alteration of image angles [14]. This algorithm consists of several stages, in the following.

1. ***Scale Space ExtremaDetection :***This stage is used to find all the scale and location of keypoints in the image. The scale of the image on Scale Space Extrema Detection is represented by an octave symbol or called a level. The first Octave has an actual image size. For the second octave, the image will be reduced to half the image in the first octave. In this stage, each image is made into 4 octave by adding Gaussian Blur function. The Gaussian Blur method is one of the filters used to reduce noise and detail levels in an image [15].
2. ***KeypointLocalization :***This stage is used the development of the D space scale function.Furthermore, the functional value of the extremum, D ((x)) is useful for rejecting the unstable unstable with the low contrast.
3. ***Orientation Assignment :*** This stage is used to find the magnitude gradient m (x,y) and its orientation from each image, L (x, y).

Next, steps are taken to measure the equality of the vector feature value of each keypoint in the test image of the train image. The highest vector equality value will be the result of letter recognition. The accuracy of the letters recognition results from the comparison of the detected letters correctly, with the overall image used in the data. The value of error in the results of the acquisition obtained through the difference of the overall data and the results of letters characters are well recognized. The error values include the number of letters that are identified with incorrect results, and can't be recognized.

III. Result

The process of preprocessing is performed by removing the ornament from the character of the letter. The removal of these ornaments would not work properly. Some results from the removal of the ornaments are shown in Fig 3.

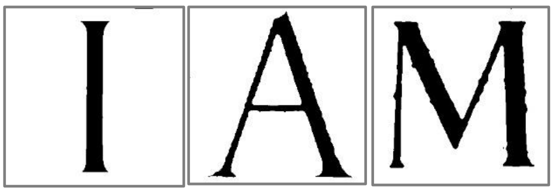


Fig 3. The result after the removal

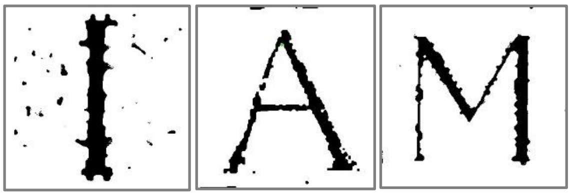


Fig 4. The removal of imperfect ornament

Fig. 3 shows some perfectly erased images. Ornaments in the image can be erased perfectly, hence it leaves only the shape of the letter characters ready to go into the pixel change stage. In the process of removal, the erosion stage plays an important role to remove a lot of residual ornaments.

While Fig. 4 shows the character of the letters with the removal of imperfect ornaments. The imperfect elimination can be caused by too complicated or contrasting images so that the ornament is difficult to separate from the letter. This failure occurs on average in the erosion stage, where the system is unable to completely erase the ornament.. The existence of this ornament will affect the point of position keypoint. Where in some cases, the keypointhits on the remaining point of ornament around the letter. In addition, the imperfect erasure also resulted in the truncation of some line parts of the character letters.

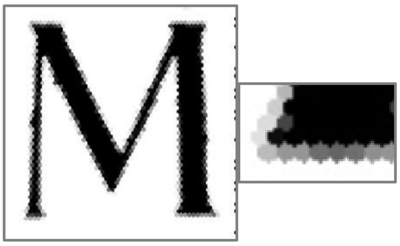


Fig 5. The hexagonal pixel letter

Fig. 5 shows an example of a M image whose pixel shape has been converted to hexagonal pixel. At this stage, square pixels are converted into hexagonal pixel shapes. Each point is moved and the intensity of the square is chosen to create a hexagonal shape of the same intensity. With the convolution, the pixels obtained will be more dense, detailed, and accurate. Through the hexagon form, the feature extraction results will increase.

Furthermore, the image with the hexagonal pixel will be extracted feature by Scale Invariant Feature Transform (SIFT) method to get the desired keypoint. The keypoint obtained will be matched with the training image.

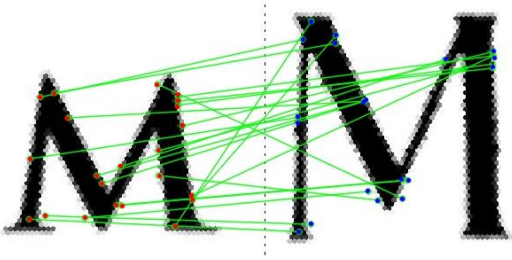


Fig 6. The matching keypoint in letter M

Fig. 6 shows an image of the letter M with a hexagonal pixel that is identified using the SIFT method. In hexagonal images, a low contrast keypoint will not be eliminated as in the basic SIFT method. The thickness of the character line makes it easier to recognize. In addition, the clean font condition of the rest of the ornament, and the uncut letter line will also facilitate the recognition process. Selection is based on keypoint with high contrast and has unique features. When one of the keypoints is detected, the orientation will be marked on each other keypoint to produce properties that are invariant to rotation.The recognition results indicate that the letter M is correctly identified by the number of matching keypoints of 22. The detected keypoint averages are spread at the angle point of the letter character.

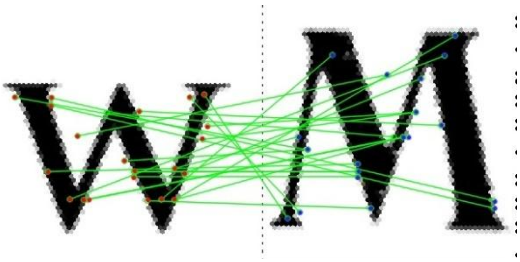


Fig 7. The matching keypoint in letter W

While Fig. 7 shows one of the characters of the letter M that is recognized as the letter W. This can be due to the form of two letters that are too similar. The results show that the SIFT method is not distorted by form and rotation. That is, the letters remain recognizable even though the character's shape is distorted by rotation. For letters with similar shapes and different results if in rotation, it will cause the letters to be incorrectly recognized. This recognition error also tends to occur in the letter N which is recognized as letter W or Z, and the letter W as the letter Z. Another recognition error occurs if there is a similar form to the letter character. This error occurs in the letter V that is recognized as W. In both letters, it is found similarity where the letter V is half of the letter W. This error also occurs in the letter I. The letter I that consists of only one vertical line causes this letter is recognized as other letters that also have vertical lines, such as N, H, and K.

The size of the keypoint slightly affects the truth of the character recognition result. The greater the number of keypoints detected, the easier it is to recognize. But it does not guarantee the truth of the results of the recognition.This is shown in Fig. 6, even with fewer number of keypoints, but letter characters are well recognized. While in Fig. 7, with a larger number of keypoints, letter characters are recognized as different letters.

Table no 1 : Records the result of ornamental letter recognition. The result of letter A, H, K, M, N, T, Y, Z are better than the other letters. Besides, The best result is in letter W, which all the sample recognize as a true value. From the total 100 data, all the letters can be detected.

Table no1: The recognition result of Hexagonal pixel and SIFT in ornamental letter

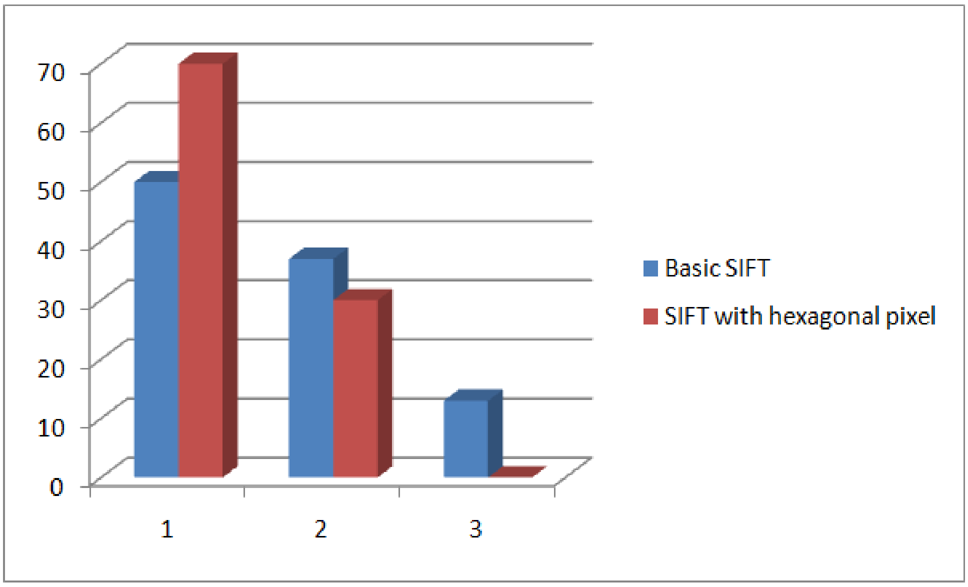
Letter	Amount of data	True	False	Can't be detected
A	5	2	3	-
B	5	-	5	-
C	2	-	2	-
D	4	-	4	-
E	5	-	5	-
F	3	-	3	-
G	3	-	3	-
H	6	2	4	-
I	6	-	6	-
J	2	-	2	-
K	5	4	1	-
L	4	-	4	-
M	8	1	7	-
N	5	4	1	-
O	3	-	3	-
P	3	-	3	-
Q	3	-	3	-
R	2	-	2	-
S	5	-	5	-
T	3	1	2	-
U	2	-	2	-
V	5	-	5	-
W	5	5	-	-
X	1	-	1	-
Y	2	1	1	-
Z	3	1	2	-

The comparison between the basic method and proposed method

Table no 2:Records theresult of each point for comparing the basic method SIFT with the proposed method (SIFT with hexagonal pixel). From 100 data, with basic method SIFT, its about 50 data can be detected as true, 37 as false, and 13 data can't be detected. Then, with combination of SIFT and hexagonal pixel, 70 data have true value, 30 data false, and all the data can be detected. Hence, the matching keypoint of the letter in basic SIFT is 239, while the matching keypoint in proposed method is 548. The letter that can't be detected in basic SIFT is 13, while in the proposed method, there's no letter that can't be detected.

Table no2: Records the Comparison between the SIFT basic method with the proposed method (SIFT with hexagonal pixel).

	Method	
	Basic SIFT	SIFT with Hexagonal Pixel
True	50	70
False	37	30
Can't be detected	13	0



IV. Discussion

The result of using Hexagonal Pixel is able to improve the feature extraction process, according to the goal to be achieved. The number of keypoints increased by 309, or about 50%. The deployment of keypoint on the combined SIFT and hexagonal pixel methods is much better than in the basic SIFT. Where on the basic SIFT, the fall of the keypoint is still centered at one point. In the combined SIFT and Hexagonal Pixel methods, all 100 letters can be recognized. While on the basic SIFT, there are still 13 unrecognize images. The basic SIFT method eliminates keypoints that have low contrast values, causing many undetected keypoints, thus decreasing the result of letter character recognition.

In addition the error value is reduced by about 0.6% of the basic SIFT method. The average error occurs in letters that have similarities (M, N, W, and Z), as well as letters that have a curved shape (B, D, G, J, P, Q, S). In letters that have curves, almost all letters are not able to be recognized well. The results of the recognition also deviated far from the letters. However, the amount of keypoint obtained from the letters is still quite large.

These results show that the SIFT and hexagonal pixel method used to increase the number of keypoint in the form of letter characters, and able to improve the accuracy of the recognition character of ornamental letters. The accuracy can be enhanced by the addition of methods that can overcome the rotational changes, and can recognize letters that have similar shapes.

V. Conclusion

The use of the SIFT method combined with Hexagonal Pixel is able to make the recognition of ornamental letters better. This can be proved by increasing the accuracy of 20% comparing to the SIFT basic method. The number of keypoints increased by approximately 50%.

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