THINNING STENTIFORD ALGORITHM FOR KINTAMANI INSCRIPTION IMAGE SEGMENTATION

Christina Purnama Yanti[1]; I Gede Andika[2]

[1]Technical Information Program, [2]Computer System Program
STMIK STIKOM Indonesia, Bali, Indonesia
http://stiki-indonesia.ac.id
[1]christinapy@stiki-indonesia.ac.id, [2]gdandika@stiki-indonesia.ac.id

Abstract— *In the copper, inscription contained writing strokes that have high historical value. Age and environmental factors cause damage to the inscription surface and also reduce the appearance of images and letters. One way to preserve it is to carry out the process of converting it into digital format. The use of the morphological operation method is very suitable to be used to improve the shape of the letters in the copper inscription. The morphological operations performed in this study were the Thinning Stentiford algorithm. Based on research that has been done, it was concluded that the Thinning Stentiford algorithm has succeeded in segmenting the letters that exist in the Kintamani copper inscription. However, there are some letters are not well segmented. This is due to the inscription background color and carved letter colors that don't have significant differences. Testing the time it was concluded that the greater the size of the image and the more letters will be segmented, the longer the processing computing..*

Keyword*: Thinning Stentiford, Segmentation, Copper Inscription*

Abstrak—Dalam prasasti tembaga terkandung guratan tulisan yang memiliki nilai sejarah yang tinggi. Faktor usia dan lingkungan menyebabkan kerusakan pada permukaan prasasti dan juga mengurangi tampilan gambar dan huruf. Salah satu cara untuk melestarikannya adalah dengan melakukan proses pengubahan kedalam format digital. Penggunaan metode operasi morfologi sangatlah cocok digunakan pada perbaikan bentuk dari karakter huruf yang ada pada prasasti tembaga. Operasi morfologi yang dilakukan pada penelitian ini adalah algoritma Thinning Stentiford. Berdasarkan penelitian yang telah dilakukan, didapatkan kesimpulan bahwa algoritma Thinning Stentiford telah berhasil melakukan segmentasi terhadap karakter huruf yang ada pada prasasti tembaga Kintamani. Namun terdapat beberapa karakter huruf yang tidak tersegementasi dengan baik. Hal ini disebabkan warna background prasasti dan warna pahatan karakter yang tidak terlalu memiliki perbedaan yang signifikan. Pengujian waktu didapat kesimpulan bahwa semakin besar ukuran citra dan semakin banyak karakter huruf yang akan disegmentasi, maka waktu komputasi pemrosesan semakin lama.

Kata Kunci: Thinning Stentiford, Segmentasi, Prasasti Tembaga

INTRODUCTION

As one of the historical heritages, copper inscriptions are found in various countries, one of which is Indonesia. In the copper inscription contained writing strokes that have high historical value. Age and environmental factors cause damage to the inscription surface and also reduce the appearance of images and letters (Rasmana, Suprapto, Purnama, Uchimura, & Koutaki, 2017) . Ancient manuscripts such as copper inscriptions need to be rejuvenated to preserve them because copper inscriptions that are decades old are more prone to damage. One way to preserve it is to carry out the process of converting it into digital format (Kuswandi & Fadillah, 2019). Researchers can use the text for the scientific research process (Novarimawan, 2018). Appropriate image processing methods greatly affect the results of segmentation of an image, especially color and textured images. Morphology becomes one of the aspects in image processing besides grayscaling, thresholding, binarization and many other stages that are developed. The use of morphological operation methods is used to learn about the structure and shape of an object (Sihombing, Buulolo, & Siburian, 2018). It is very suitable to be used to improve the shape of the letters in the copper inscription. Morphological operations carried out in this study are by implementing the Thinning Stentiford algorithm. Thinning Stentiford algorithm works by reducing the area from the edge of the object in the form of an image to the remaining center or can be called a framework (Prabangkoro, 2008).

Several previous studies have researches related to image segmentation. Research by

Susijanto, with the title "Texture Detection for Letter Carving Segmentation of Ancient Copper Inscriptions" conducting copper segment image inscription research using feature extraction methods (Rasmana et al., 2017). Another research from Arifianto with title "Segmentasi Aksara Pada Tulisan Aksara Jawa Menggunakan Adaptive Threshold"(Arifianto, 2016) who conducts research on the existing letter segmentation in books using the thresholding method. There are no studies that have conducted morphological implementation of ancient copper inscription images using the Thinning Stentiford algorithm and using the HSV color space.

The purpose of this study is to implement the Thinning Stentiford algorithm to obtain segmentation results from ancient copper inscription images.

MATERIALS ANDA METHODS

The research framework is divided into several stages, namely: the preprocessing (1), converting RGB color to HSV color (2), Binarization and Complement (3), Implementation of Dilation Erosion morphology and Thinning Stentiford algorithm (4).

A. Preprocessing

The first step taken is to do preprocessing where it starts with digitizing an ancient copper inscription image at the Denpasar Archeological Center using a digital camera. Inscription image in .JPG format and in RGB color. Then cropping the area as a sample in the next process. Besides, the reduction of noise in the image is done using the Median Filter method.

Source: (Yanti & Andika, 2019)

Picture 1 Image of Copper Kintamani Inscription

B. Converting RGB Color to HSV Color

The next step is to change the initial inscription image in the form of RGB to HSV (Hue, Saturation, Value). The best image results will be processed to the next stage.

C. Binarization and Complement

The image in the form of Value is then converted into a black and white form in the binary operation which will produce a binary image so that later it is easier and faster to process. Binary images are digital images that have only two possible colors, namely black and white. Only 1 bit is needed to represent the value of each pixel of a binary image. Forming a binary image requires a gray boundary value that will be used as a benchmark value.

Pixels with a gray degree greater than the boundary value will be given a value of 1 and instead a pixel with a gray degree less than the boundary value will be given a value of 0. The equation for binarization can be seen in the formula below:

$$f(x,y)^1 \begin{Bmatrix} a_1, f(x,y) < T \\ a_2, f(x,y) \geq T \end{Bmatrix} \quad \ldots\ldots (1)$$

Binary operation makes the image into a two-dimensional array of elements 0 and 1 as a representative of the binary image where the results are written on the inscription image in black while the background is white. To be able to do the next process, the image that is already in binary form is carried out by the complement process using the clomplement syntax so that the result is in the form of white color and the background black. The complement of a gray level image is negative from that image. The function to produce the complement of a gray level image is:

$$y = L - x \quad \ldots\ldots (2)$$

where L is the highest level or level of pixels (255) and x is the value of the input image pixel.

Source: (Novarimawan, 2018)

Picture 2. Complement Matrix

D. Implementation of Morphology

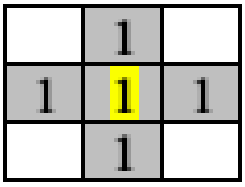
This study implements three types of morphology that can help to improve the letters that exist in ancient copper inscriptions. Image morphology is a very extensive image processing operation that modifies images based on shapes. This is considered as one of the most useful data processing methods in image processing. Image morphology techniques verify images in the form of structuring elements. This arrangement element is applied to all possible locations of the input image and produces the same size output. In this technique the value of the output image pixel is

based on the same pixel as the input image with neighbors. This operation produces a new binary image where if the test is successful it will have a zero pixel value at that location in the input image (Chudasama, Patel, & Joshi, 2015).

E. Dilation

Dilation is a technique for enlarging object segments (binary images) by adding layers around the object (Priandini, Nangi, Muchtar, & Sari, 2018). The type of dilation used in this study is diamond dilation with a value of R = 1.

```
R=1;
se=strel('diamond',R);
morp=imdilate(z,se);
```



Source: (Chudasama et al., 2015)

Picture 3 Dilation Matrix

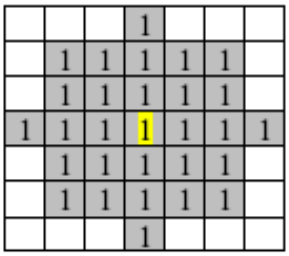
F. Erosion

Erosion or erosion is the opposite of dilation, a technique that aims to reduce or erode the edges of objects. Or by becoming a point object (1) that is neighboring with a background point (0) being a background point (0)(Priandini et al., 2018). Erosion causes objects to shrink or become thin. Erosion essentially erodes the foreground boundaries resulting in a pixel area that shrinks in size and the whole area becomes larger (Chudasama et al., 2015).

$$A\Theta B=\{x|(B)x\cap Ac\neq\phi\} \quad (3)$$

The type used by erosion is the type of disk where the value K = 3

```
K=3;
se1=strel('disk',K);
morp2=imerode(morp,se1);
```



Source: (Chudasama et al., 2015)

Picture 4. Erosion Matrix

G. Thinning Stentiford Algorithm

After the morphological process of dilation and erosion, thinning is then performed. Broadly speaking, thinning can be interpreted as the process of reducing the area of the edge of an object in the form of an image until what remains is only the centerline or can also be referred to as a skeleton or skeleton. In a concept that has been developed by many people, J.R. Parker (1997) argues that not all objects can be subject to thinning operations, and the results of the thinning operations themselves, which are called frameworks, have the possibility of not functioning in all situations. J.R. Parker (1997) also suggested that thinning is an algorithm to identify the framework of an object, thinning operation itself is not defined by the algorithm used(Prabangkoro, 2008). The method used is the Thinning Stentiford algorithm. The Thinning Stentiford algorithm was first introduced by F. W. M. Stentiford and R. G. Mortimer. The Stentiford algorithm uses a 3 x 3 template to do an image match. When a match occurs, the midpoint of the 3 x 3 pixel is deleted (the color is changed to white)(Fakhrina, Rahmadwati, & Wijono, 2016). To get good results, it is required to carry out a thinning operation. Thinning is an algorithm used to remove selected foreground pixels from binary images (Raid, Khedr, El-dosuky, & Aoud, 2014). Thinning is almost similar to the erosion method. The algorithm of Thinning Stentiford is as follows (Fakhrina et al., 2016) :

1. Find the pixel location (i,j)
2. If the middle pixel is not the endpoint, and connectivity number = 1 then marks this pixel for further removal.
3. Repeat steps 1 and 2 for all pixel locations that match the template.
4. Repeat steps 1 to 3 for the next template.
5. If there are pixels that have been marked to be removed, then delete them by specifying them to be white.
6. If any pixels have been removed in step 5, repeat the previous process from step 1; until it stops.

RESULTS AND DISCUSSION

The proposed method is simulated with the help of Matlab 2017b software. Before the segmentation process is carried out, the copper inscription image that has been digitalized will go through the preprocessing stage, namely cropping to determine the Region of Interest image that will be segmented. In addition to the cropping stage,

there is also a phase of reducing noise in the image using the Median Filter method, so that the segmentation results obtained are better than images that still have noise. After the preprocessing process, image conversion is then performed where the initial image that has been digitalized in the form of an RGB image is then converted into an HSV image.

Table 1. Table of Results for Convert RGB to HSV Color

No.	Color	Image
1.	Original Image	
2.	Hue	
3.	Saturation	
4.	Value	

Source: (Yanti & Andika, 2019)

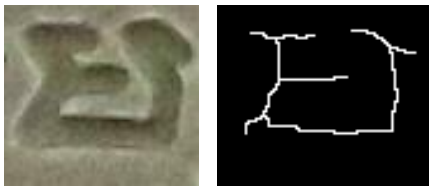
From the conversion results above, it can be seen that the image in the Value section has the best results and the script looks more clear so that the image in the Value section will be processed at a later stage. To make it easier in the segmentation process, the image in the Value section which is a gray image will be changed to black and white or through the binarization step using the thresholding method.

Source: (Yanti & Andika, 2019)
Picture 5. Result of Binary Image

From Figure 5 it can be seen after going through the process of thresholding the image turns black and white where the letters are black and the background is white. So that the results obtained are optimal, the thinning process requires an image where the background is black and the letters are white. Therefore a complementary process is carried out. The results of complement can be seen in Figure 6.

Source: (Yanti & Andika, 2019)
Picture 6. Result of Complement Image

The image that has gone through the process of binarization and complement is the time to implement the morphological process. The process of morphology aims to get the shape and structure of the ancient letters that exist on the inscription. Next is the thinning process. The thinning algorithm used is the Stentiford Thinning algorithm. Tests carried out with four samples of ancient copper inscription images. The following are the results of testing image segmentation using the Thining Stentiford algorithm.



Source: (Yanti & Andika, 2019)

Picture 7. Result of Thinning Stentiford Implementation

From the test results of some of the images above, it appears that all letters can be detected and successfully segmented using the Thinning Stentiford algorithm. All test results with the number of letters detected are attached in Table 2.

Table 2. Table of Test Results Detected

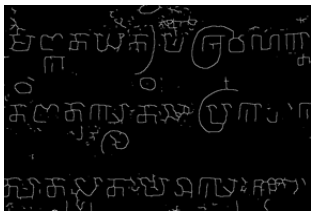
No.	Number of Letters	Detected Letter	Percentage
1.	1	1	100%
2.	2	2	100%
3.	6	6	100%
4.	16	16	100%
5	29	22	75%
6	42	32	76%
7	73	33	45%

Source: (Yanti & Andika, 2019)

Based on the test results, the Thinning Stentiford algorithm has been able to detect the letter. However, some things still cannot be detected due to changes in the plate's background color that resembles the color of the letter so that some areas of the background are detected as areas of the letter. The gray degree characteristic possessed by the copper inscription image also influences the determination of thresholding to determine the target candidates and the process of searching for contour points so that the search process for the contour points to be found is not appropriate. This can cause the discovery of contour points that deviate from the path of the object's edge.

Then time consuming testing is done. Testing is done to find out how fast the computation of the Thinning Stentiford algorithm. As a sample, five copper inscription images were tested to test the computational time of the Stentiford Thinning algorithm.

Table 3. Result of Time-Consuming

No.	Image	Time-Consuming (sec)
1.		5
2.		7
3.		12
4.		31
5		84

Source: (Yanti & Andika, 2019)

From the test results above, it was found that the Thinning Stentiford algorithm has a long computational time. The more letter that is segmented, the more time is needed.

CONCLUSION

Based on research that has been done, it can be concluded that the Thinning Stentiford algorithm has succeeded in segmenting the letters in the copper inscription of Kintamani. However, some letters are not well segmented so that the shape of the letters is not visible. This is due to the inscription background color and carved letter colors that do not have significant differences and because the characteristics of the inscription are slightly damaged by the presence of patina. For time testing, it can be concluded that the larger the image size and the more letters that will be segmented, the longer the processing computing time. The next research development is expected to be able to detect each letter in the Kintamani inscription so that it can assist researchers in analyzing the copper inscription Kintamani.

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