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ANALYSIS OF ADAPTIF LOCAL REGION IMPLEMENTATION ON LOCAL THRESHOLDING METHOD

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ABSTRACT

Thresholding is a simple and effective technique for image segmentation. Thresholding techniques can be grouped into two categories, global thresholding and local thresholding. All local threshold method generally begins with determining thresholds in each pixel by checking the area centered on the pixel, using a box shape (x, y) which is fixed by the size of the neighborhood "b". If the neighborhood is very small, then the algorithm will be sensitive to noise and excessive segmentation occurs. Whereas, if the size of the neighborhood is very large then the algorithm will apply resemble the global threshold method. In this study, we propose a method of calculation of Local Adaptive Region, to determine the value of each pixel that is flexible neighborhoods, where each pixel has values different neighborhoods based on the value of the standard deviation region. Adaptive method on the local region thresholding consists of several processes, namely: Image Enhancement, Adaptive Local Region and thresholding. Based on evaluation of ME, image result of threshold using the Adaptive Local Region method, giving an average ME smallest value, that is 16.99% at Niblack method and 19.46% at Sauvola method. And on evaluation of the RAE, image result of threshold using the Adaptive Local Region method, giving an average RAE smallest value, that is 15.26% at Niblack method and 25.58% at Sauvola method. In addition, the results of trials with various noise variance represent that the method of Adaptive Local Region resistant to noise.

***Keywords**: Thresholding, Adaptive Local Region, Niblack, Sauvola*

I. Introduction

IN digital image processing, a method often used to detect objects in the grayscale image is with thresholding method, where each pixel is then separated into a background object [1]. An image thresholding results can be presented in the image histogram to determine the spread of the intensity values of the pixels on an image / specific part of the image

Binarization grayscale images method can be grouped into two broad categories: the methods of global thresholding and local thresholding method [2]. The global method is a method to find a single threshold value for the whole image [3]. This global thresholding method can be adapted to calculate the local boundary, where the value of different thresholds used for each region in the image. This method is referred to as the Local thresholding. Thresholding locally made to areas in the image. In this case, the image be broken down into small parts, then thresholding done locally.

Local thresholding method generally uses a threshold to the region by analyzing a box-shaped area centered on the pixel (x, y) with the value of neighborhood / neighborhood "b" [2]. Local thresholding method will work well if the value of a well-defined neighborhood. The amount of the neighborhoods should be adjusted to the size of the object.The determination of the value of the neighborhood is done by repeated experiments to obtain the optimal segmentation results [4]. If the value is too great neighborhood, then the local thresholding method will work with slow and small objects that have low contrast against the background value will be difficult to detect, especially if the object is close to the larger object with high contrast value. Conversely, if the value of neighborhood is too small, there will be an error in the determination of the borders of the object is large, resulting in large errors in identifying objects. This error also occurs in thinking about the image noise. Deficiencies in determining the value of the neighborhood can be solved if the size of the local region's air hub at pixel (x, y) has an area that is dynamic, according to the characteristics of each area. In this study, we proposed a method of calculation of an adaptive local region, where each pixel has values different neighborhoods based on the value of the standard deviation region. Adaptive Methods in thresholding local region consists of several processes, namely: Image Enhancement, Adaptive Local Region and thresholding. To determine the performance of the method, is used as a method of ME and RAE accuracy evaluation system.

II. Previous Research

Previous research has been conducted related to local thresholding method. Niblack method using the average value and standard deviation of each pixel in an area with a predetermined size of grayscale images. The amount of the neighborhoods must be small enough to be able to identify small objects and large enough to be able to eliminate the noise [5]. Disadvantages of this method is the high sensitivity towards the size of the neighborhood and the low resistance to noise in the binary image.

Niblack method capable of being upgraded by Sauvola with remove noise in homogeneous regions with an area larger than the size of the neighborhood. This method proposed the hypothesis that the object pixel has a value close to 0 and the background pixel has a value of 255. In areas with high contrast values, Sauvola methods able to produce the same value with Niblack method. The difference in this method will be seen in the area with a low contrast value, where the value of the local threshold is lower than the average value of the area so that it can be separated from the background. However, this method has the same drawbacks with Niblack method, the output from this method greatly influenced in large regions of each pixel are fixed [6].

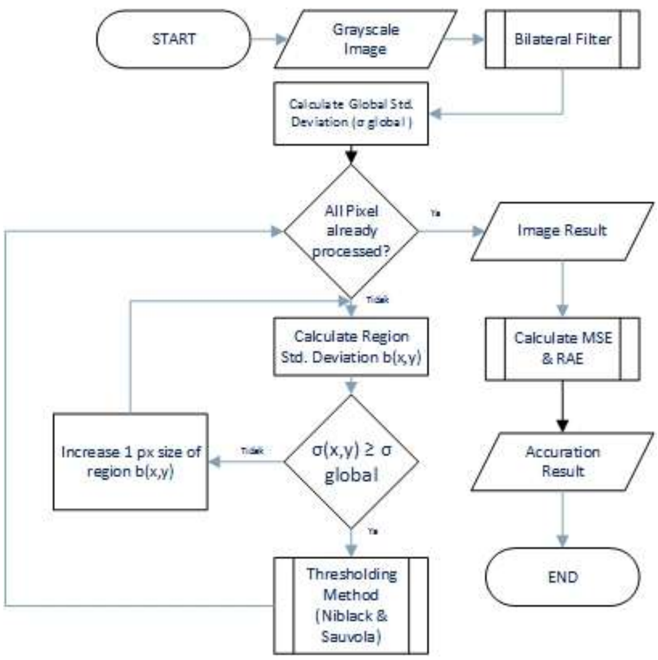

Figure 1. Design System

III. Design System

The system design of the proposed method can be seen in Figure 1. Overall, the system in this study is divided into several sections, namely: pre-processing using Bilateral Filter Method, the calculation of adaptive local region, and the calculation of the local thresholding.

A. Bilateral Filter

Bilateral filter method is used at the stage of pre-processing. The purpose is to smooth the edges in the image while maintaining the sense of a linear combination is not close to the value of the image.

The underlying idea of the bilateral filter is a filtering process in the range of an image, while the traditional filters do in its domain [8]. Two pixels can be close to each other (occupying the spatial location / room that was close), or they can be similar to each other (having a value close / similar). Proximity refers to the area around the domain, while the similarity in the area around the range. The traditional filter is a filtering domain and performs proximity by comparison with a coefficient of the pixel values that match the distance. Filter range is not linear because of its weight depending on the intensity of the image / color.

The combination of filter range and filter domain is a very interesting combination that can be called a Bilateral Filter. Because bilateral filter assumes explicitly on the idea within the domain and range of functions of the image, they can apply for some of the functions defined second distance. Bilateral Filter can be defined as follows:

$$h(x) = k^{-1}(x)\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x_i)c(x_i, x)s(f(x_i), f(x))dx_i, \quad (1)$$

with normalization

$$k(x) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} c(x_i, x)s(f(x_i), f(x))dx_i \ldots\ldots\ldots\ldots\ldots \quad (2)$$

where $f(x_i)$ an input image, h(x) is the resulting image, c(x_i ,x) is a measurement of geometric proximity between x and a neighborhood center closest point x_i, $s(f(x_i), f(x))$ is a photometric measurement of similarity between the pixels in the central neighborhood of x and points nearby x_i, and k(x) is the weight for each pixel.

B. Adaptive Region Method

Various previous research has shown that the area of each pixel on the local thresholding method should be large enough to recognize the borders of the object, but not too large to be able to eliminate pixels that are not relevant (like noise). Therefore, the size of the area relevant to the characteristics throughout each pixel is required to get optimum results local thresholding.

This study proposes a method of calculating the value of the neighborhood is flexible by measuring the standard deviation σ (x, y) of each pixel region centered at (x, y).Each area has a circular area with minimum radius $R_{x,y}$, where the value of standard deviation region $\sigma_{(x,y)}$ is greater than or equal to the standard deviation (σ_I) of the image I. The radius of each pixel can be written as Equation 3.

$$R_{x,y} = \min\left\{\sigma_{(R_{x,y})} \geq \sigma_I \mid R_{x,y} > 0\right\} \quad (3)$$

This method refers to the assumption that if a gion $R_{x,y}$ has a standard deviation value greater than or equal to the standard deviation of an entire image, then in the region there is a structural information sufficient to divide a pixel into an object or background.

C. Adaptive Local Thresholding

A thresholding T(x,y) is a threshold value to change the image I(x,y) be a binary image B(x,y) as illustrated in Equation 4.

$$B_{x,y} = \begin{cases} 0 & if \ I_{x,y} \leq T_{x,y} \\ 1 & if \ I_{x,y} > T_{x,y} \end{cases} \quad (4)$$

In the Local Adaptive thresholding method, the threshold value of each pixel is calculated based on local statistics such as distance, average, or deviation from the pixels of neighborhood [9]. One method that is included in the Local Adaptive thresholding method is a method of Niblack and Sauvola..

1) Niblack Method

In this method, the value of Y (x, y) at pixel (x, y) is calculated using the adjacency (w x w), as in the following equation:

$$T_{x,y} = m_{x,y} + k\delta_{x,y} \quad (5)$$

where $m_{x,y}$ is the average value of local and $\delta_{x,y}$ ais the standard deviation of the pixel *(x,y)* in an area (w x w) and k is a value bias. The standard value of k is -0,2 and w is 15.

2) Sauvola Method

In Sauvola method, value *T(x,y)* is calculated using the average value of local $m_{x,y}$ and the standard deviation value $\delta_{x,y}$ in area (w x w) as in the following equation:

$$T_{x,y} = m_{x,y}\left[1 + k\left(\frac{\delta_{x,y}}{R} - 1\right)\right] \quad (6)$$

Where R is the maximum value of the standard deviation of the image and a standard k value is 0.5 [1] [9].

IV. Experiment and Result

Region Local Adaptive method was tested using 10 images that have varying pixel intensity values (Figure 2) by comparing the results of image segmentation using Local Adaptive Region on Local Thresholding method with the image of the local thresholding segmentation with a value of neighborhood regulars. The great value of neighborhood still used is the minimum value of neighborhood that is 3 and the value used in several other studies [1] [5] [9], which is 15.

Groundtruth imagery used, manually generated based on the original image as shown in Figure 3. Figure 4 and 5 indicates the resulting image thresholding method Niblack and Sauvola use neighborhood fixed value of 15. Results of Adaptive Methods Local Region image shown in Figure 6. In picture 6, Region Local Adaptive method paired with Sauvola thresholding method. To compare the quality of the image thresholding, used quantitative test using the method of misclassification error (ME) and Relative Methods foreground area error (RAE) [1] [10]. Misclassification Error (ME) is used for error ratio corresponding background pixels are set as foreground and conversely. ME formula is defined as follows:

$$ME = 1 - \frac{|B_O \cap B_T| + |F_O \cap F_T|}{|B_O| + |F_O|}, \quad (8)$$

where Bo is a background of the image of the ground truth, Fo is a foreground of the image of the ground truth, BT is a background of the image are tested (the image of the threshold) and FT is a tested foreground of the image (the image of the threshold).

While Relative foreground Area Error (RAE) is used to calculate the discrepancy between the image of the threshold with an image of the ground truth. RAE formula is defined as follows:

$$RAE = \begin{cases} \dfrac{A_O - A_T}{A_O} & if \ A_T < A_O \\ \dfrac{A_T - A_O}{A_T} & if \ A_T \geq A_O \end{cases} \quad (9)$$

Where *Ao* is an area of groundtruth foreground image and A_T is an image of the foreground area threshold.

Table 1 indicates performance thresholding based on the value of ME and RAE for each thresholding algorithm which is a comparison between the image of the threshold with the image of his ground truth.

To test the robustness of the methods Adaptive Local Region to noise, then do a test by adding noise to the image based on the Gaussian distribution. Each image of the threshold to be tested characterized by SNR (Signal to Noise Ratio) is defined as follows:

$$SNR = \left[\frac{\sum_{x=1}^{N_x}\sum_{y=1}^{N_y} I^2(x,y)}{\sum_{x=1}^{N_x}\sum_{y=1}^{N_y}(I(x,y) - I_n(x,y))^2}\right], \quad (10)$$

where *I(x,y)* and $I_n(x,y)$ is the level of gray to the pixels *(x,y)* on the reference image and the image to be tested. N_x and N_y is the columns and rows of images.

V. DISCUSSION

According to the evaluation of ME, the image of the threshold using the Adaptive Local Region, both at Niblack thresholding method or Sauvola method, giving an average ME value the smallest. This indicates that the value of the background pixel error ratio is defined as the foreground and conversely is the smallest. Meanwhile, according to RAE evaluation, the image of the threshold with Region Local Adaptive method also provides a value RAE smallest in the second thresholding method that indicates that the suitability of the object region segmentation between the image of the threshold with the groundtruth image is greatest.

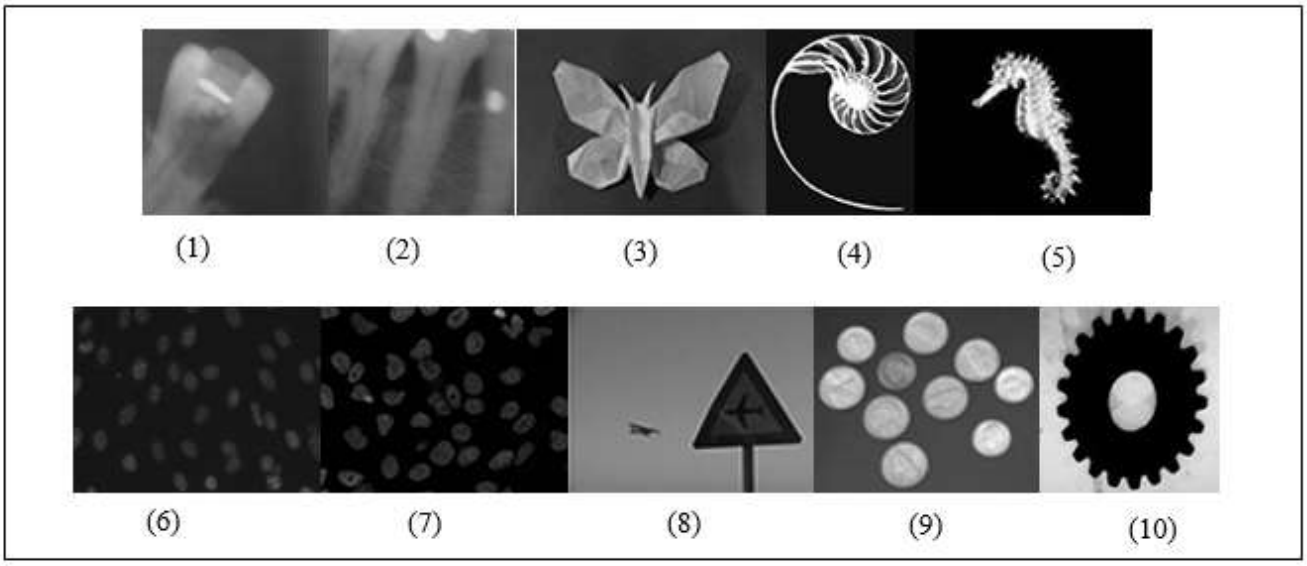

Figure 2. Original Image

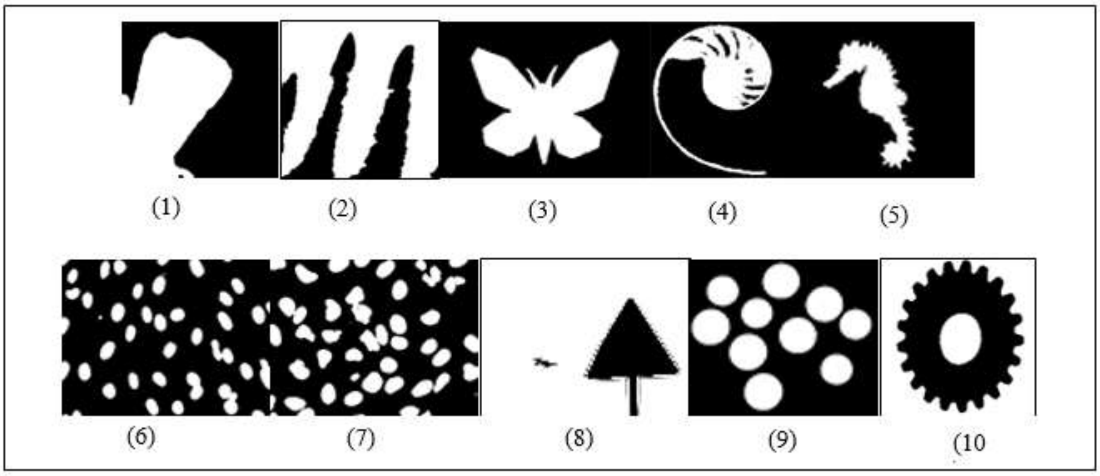

Figure 3. Groundtruth Image

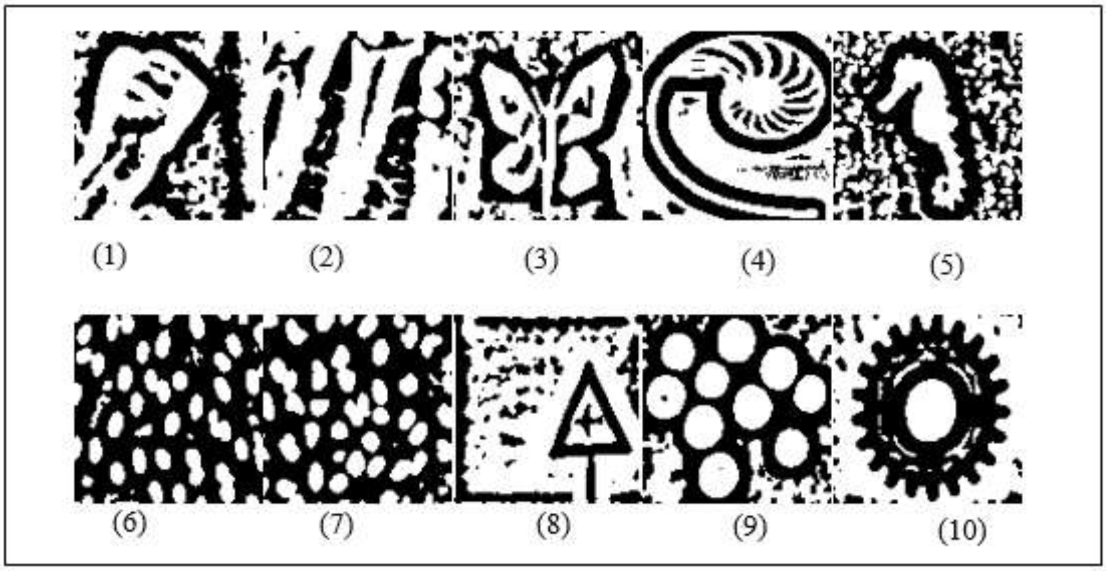

Figure 4. Thresholding Niblack Result (k = -0,2, w = 15)

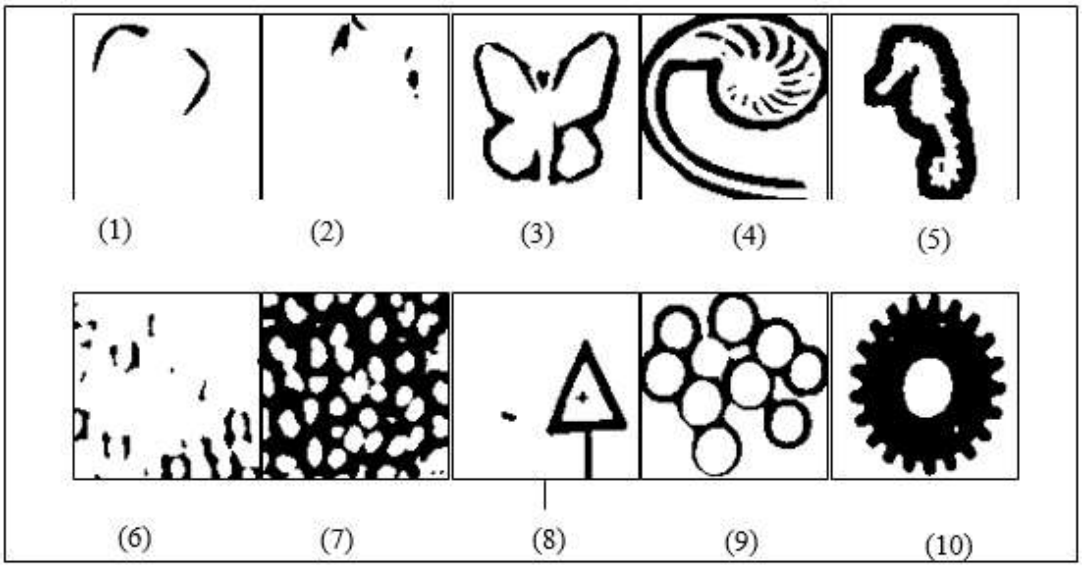

Figure 5. Thresholding Sauvola Result (k = 0,5, w = 15)

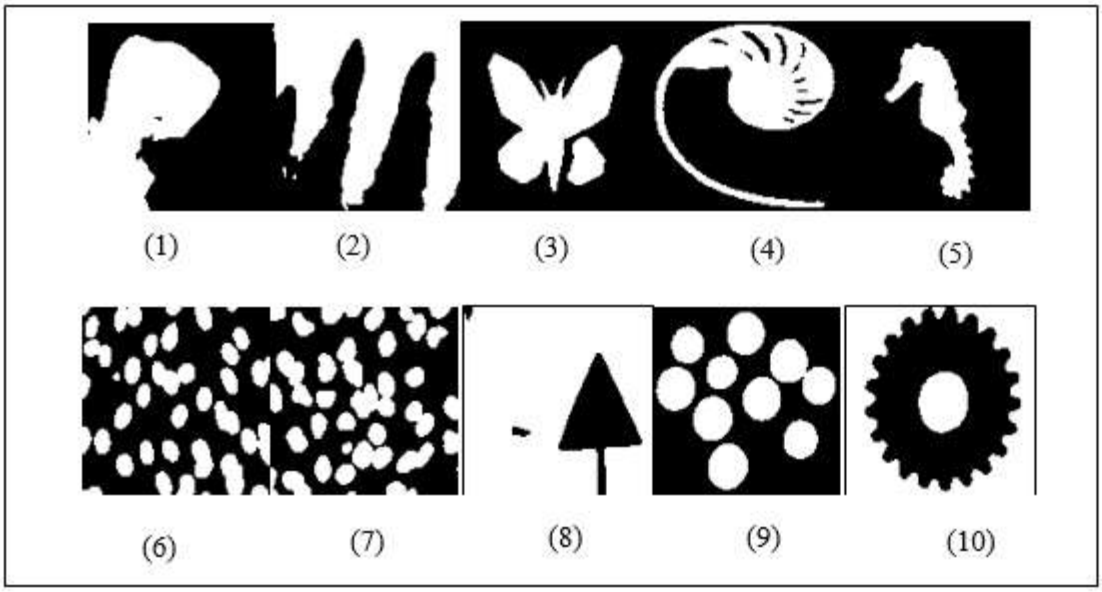

Figure 6. Adaptive Local Region Method in Thresholding NiBlackMethod (k = 0,5)

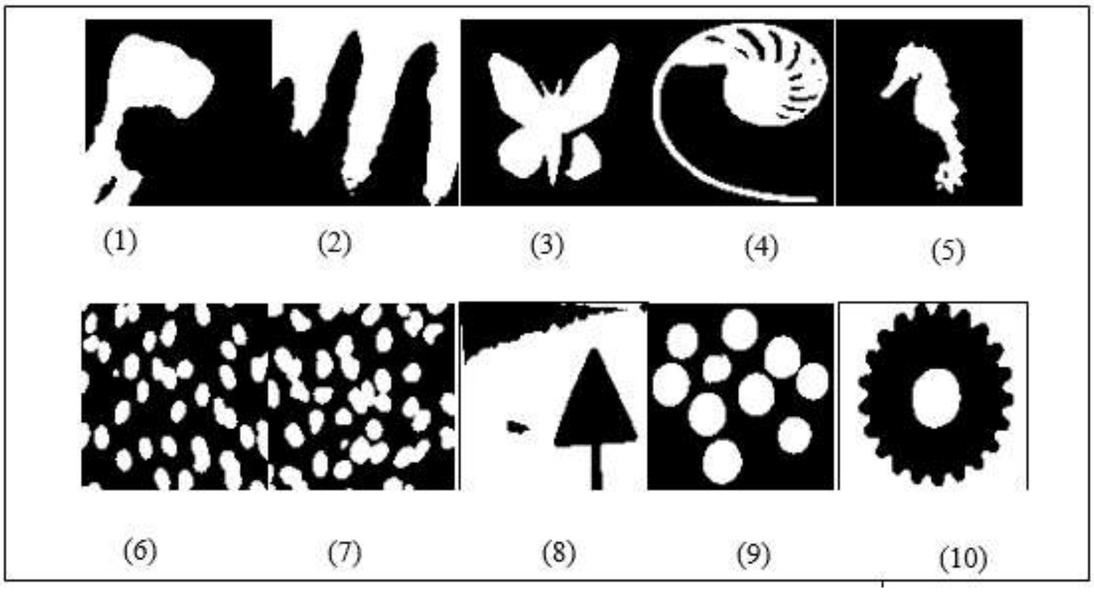

Figure 7. Adaptive Local Region Method in Thresholding Sauvola Method (k = 0,5)

TABLE I
COMPARISON RESULT THRESHOLDING

No. Image	Niblack						Sauvola					
	Fixed				Adaptive Local Region		Fixed				Adaptive Local Region	
	3		15				3		15			
	ME(%)	RAE(%)	ME(%)	RAE(%)	ME(%)	RAE(%)	ME(%)	RAE(%)	ME(%)	RAE(%)	ME(%)	RAE(%)
1	48.21	41.01	37.78	23.04	**7.57**	**13.08**	58.94	55.02.62	57.14	53.75	**17.62**	**38.88**
2	33.51	6.79	24.33	14.71	**17.46**	**23.31**	35.41	25.78	34.77	24.40	**23.33**	**31.38**
3	59.37	45.81	48.44	36.17	**12.44**	**20.36**	73.76	61.97	64.90	55.47	**12.88**	**24.60**
4	58.51	25.61	55.76	22.88	**26.40**	**23.42**	80.41	53.65	64.06	36.68	**26.37**	**29.17**
5	48.64	51.94	41.12	58.30	**10.13**	**20.85**	89.81	80.54	73.74	75.25	**10.21**	**30.57**
6	47.08	32.27	29.21	9.41	**29.67**	**3.13**	91.33	65.76	84.05	62.67	**25.74**	**19.25**
7	48.32	14.36	32.31	22.75	**30.96**	**17.78**	83.52	53.46	35.26	14.71	**30.10**	**27.61**
8	36.35	20.14	35.58	24.99	**8.59**	**4.25**	18.56	9.66	13.01	2.29	**21.51**	**19.46**
9	55.78	41.03	32.69	18.90	**16.78**	**15.78**	76.33	59.39	57.61	46.62	**16.90**	**21.85**
10	24.97	0.24	17.27	8.12	**9.90**	**10.66**	26.64	20.36	10.04	10.21	**9.93**	**13.02**
Avg	46.07	27.92	35.45	23.93	**16.99**	**15.26**	63.47	47.84	49.46	38.21	**19.46**	**25.58**

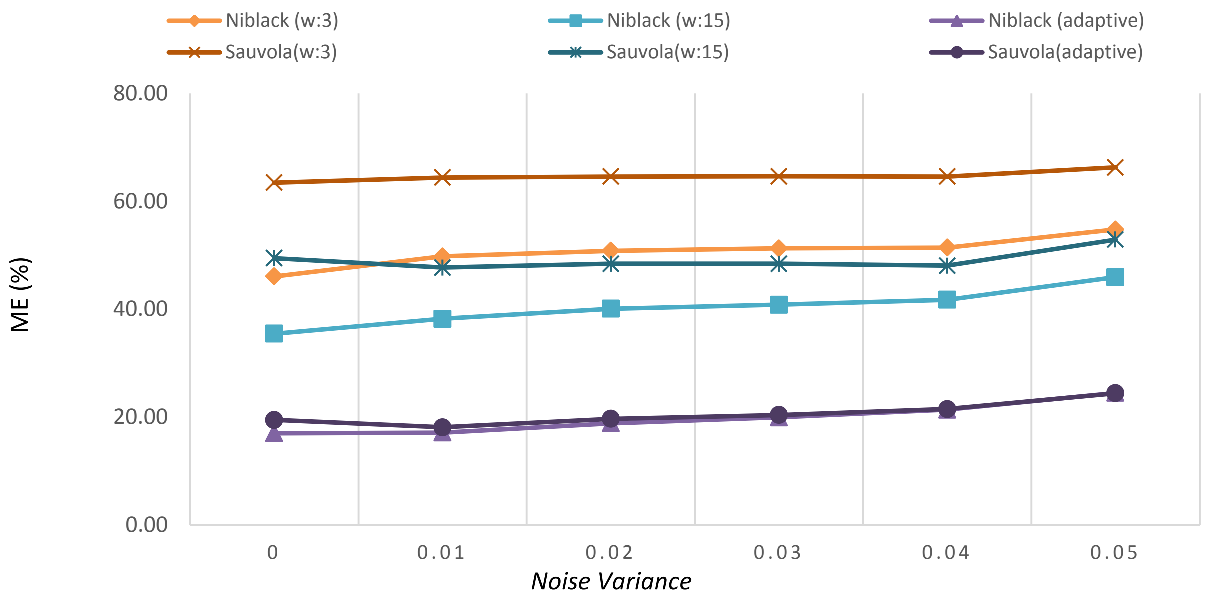

Figure 7. Graph Comparison of Results thresholding the image with some noise variance

Noise addition is done in stages with the noise variance at 0:01, 0:02, 0:03, 0:04 and 0:05. Based on the value of ME and RAE, a decrease in the performance of the Adaptive Local Region method average of 1%. Results of performance Adaptive Local Region method also proved best at Niblack and Sauvola methods test to the addition of noise variance as shown in Figure 7. The results of Niblack and Sauvola thresholding method using Adaptive Region Local produce ME values far lower than that of both methods is the value of neighborhood fixed.

VI. CONCLUSION

In this paper, the calculation method indicated an adaptive local region are suitable for use in local thresholding method. The main key to this method is the determination of the determination of the value of the neighborhood that is flexible for each pixel based on the standard deviation value of each pixel.

Based on the experiment, Niblack and Sauvola method which uses the Local Adaptive Region has a better performance than the Niblack and Sauvola method which uses a fixed value of neighborhoods. Adaptive Local Region Methods is able to provide ground truth image correspondence well. Based on evaluation of ME, image result of threshold using the Adaptive Local Region method, giving an average ME smallest value, that is 16.99% at Niblack method and 19.46% at Sauvola method. And on evaluation of the RAE, image result of threshold using the Adaptive Local Region method, giving an average RAE smallest value, that is 15.26% at Niblack method and 25.58% at Sauvola method.

Thresholding performance evaluation of the entire image to be tested with various noise variance indicates that the method of Adaptive Local Region resistant to noise. For further development, need to do research to find methods of preprocessing better than Bilateral Filter for improved performance Adaptive Local Region method. In addition, the application of the method in certain cases also needed to determine the performance of the Adaptive Local Region method.

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