Background Correction using Average Filtering and Gradient Based Thresholding

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***Abstract*—Segmentation process on the image with illumination and contrast variation problem is a very challenging task. This problem can reduce the effectiveness of segmentation result. Therefore, the implementation of the proposed method based on the background correction is able to improve the image quality and automatically increases the segmentation. The proposed method used in this study is based on mean filtering and Otsu thresholding techniques to enhance the non-uniform image for better segmentation. The proposed method used the mean value of the image to normalize the background image. Then, the resulting image from the previous step underwent the segmentation process using Gradient Based Adaptive thresholding. Finally, a comparison in term of misclassification error (ME) was calculated and compared with the six other methods. For the 'rectangles' image, our method with gradient achieved 0.050478 and it is better compared to the other six methods. However, the ME value of the 'text' image produced by our method is 0.058722, slightly higher than the Niblack's method, Chen's method and gradient based method. Therefore, it still acceptable in comparison to those methods by Yanowitz and Bruckstein's (YB) method, Blayvas's method, and Chan's method. The proposed method is better method to enhance and improved the image quality. The main impact of this study is to eliminate the illumination and normalize the contrast variation. In conclusions, the implementation of the proposed method produces an effective and efficient results for background correction and increases the segmentation result.**

***Index Terms*—Normalization; Illumination; Non-Uniform; Segmentation; Average Filtering; Binarization.**

I. Introduction

Non-uniform illumination is used to describe an image with high intensity regions in the middle of another level of intensity. In order to explore details about non-uniform illumination, two parameters need to be considered, namely the illumination normalization approach that corrects the lighting problem while retaining the characteristics of the image features and edge information. In fact, the appearance of an object can be adversely affected by the lighting. The illumination problem affects the image analysis process, especially in automatic computer based application. During the acquisition process, the images tend to encounter a non-uniform problem. This problem can severely compromise the diagnostic procedure and an automated computer-based technique is used to obtain the parameters for the diagnosis. Therefore, to overcome the limitations, researchers had been focusing on developing an efficient deblurring and devising methods for non-uniform illumination correction.

II. Literature Review

Generally, illumination correction can be categorized into two main methods; prospective correction and retrospective correction. Many researchers focus on the retrospective correction since it creates a better solution compared to prospective correction. A new method for the bi-level image to change the impact of non-uniform enlightenment, which focuses on nonlinear minimum squares that measure the binaries image and illumination problem was done by Lee and Kim [1]. Meanwhile, Wencheng and Xiaojun [2] recommended a new method for background correction by determining the low and high frequency components that amplifies appropriately based on Homomorphic filtering. The above finding is consistent with the study by Ardizzone et al. [3] . They also suggested a technique based on Homomorphic filtering to solve the illumination problem. This method is proposed to improve the basic Homomorphic filtering function that has two problems; it does not provide an indication of the cutoff frequency (CF) and introduces another artifact of the inflammation in the foreground border. In 2012, a survey on mathematical equations for homomorphic filtering in the frequency domain for a different application was studied by Saleh and Haidi [4]. Hossein and Ali [5] stated that the significant relationship between homomorphic filtering and bicubic interpolation is to normalize a large illumination variation. The illumination normalization method based on bilateral filtering was proposed [6] and it is very effective to normalize the luminosity and enhance the contrast variation. The latest work reported in 2013, Vlachos and Dermatas [7] pointed to eliminate the effect of non-uniform illumination algorithms based on Fuzzy C-Means (FCM). In this study, brightness corrections are carried out by the inverse of the image formation, replicating the FCM convergence. Besides that, Yadong et al. [8] proposed a new algorithm to improve the contrast based on colour combination mapping and decomposition of space-based tone mapping. In order to detect the edges in the face recognition field, the non-uniform images corrected based on fuses merits of colour (Red, Green and Blue), normalization (Nrgb) and Gamma Correction (GC) were reviewed by Chude-Olisah et al. [9]. Another algorithm for illumination correction was proposed by Glaister et al. [10]

which calculated the underlying illumination through modeling stages. This method involves three levels; estimate the illumination map using non-parametric, determine the quadratic surface reflectance through parametric modeling and calculate the final illumination estimation. In retinal image application, Azani et al. [11] published a paper in which they described a method based on superimposing between low pass and Gaussian filtering to improve the image quality. Tan et al. [12] proposed a new model based on the dependency of reflectance on IL through rotating data in an IL-reflectance space to eliminate the empirical correlation between reflectance and illumination condition.

In conclusion, based on the review, the luminosity and contrast variation should be normalized prior to the segmentation process in order to produce a good segmentation result. In the image processing field, the illumination problem is a crucial problem and challenging task for researchers which needs to be considered before segmentation process. Literature reviews have indicated various methods that have been proposed to solve the illumination effect but most of the researchers have problem to determine the cutoff frequency or the threshold value to separate between the background and foreground. It is difficult to obtain the best cutoff frequency and the threshold value in the non - uniform image, especially if the foreground intensity appears almost similar with the background intensity image. In summary, many interesting results have been reported indicating the potential to reduce and eliminate the illumination. However, most of the studies in the open literature did not simultaneously examine the contrast variation and luminosity at the same time. In this paper, we proposed a new method based on mean filtering for background correction to normalize the non-uniform image from illumination and contrast variation before finding the final result using Otsu method for segmentation process. The proposed method focuses on the background correction to produce a good contrast variation image and then utilizing gradient based thresholding to test the effectiveness of the proposed method. The work presented in this paper follows the following organisation: Section II explains the literature review folllowed by Section III that describes the proposed method. The resulting performance is explained in section IV, the discussion of the finding study are preesnted in section V and finally section VI elaborates the conclusion of this work. We compare the Misclassification Error (ME) result with six methods. Finally, section V presents the conclusion.

III. METHODOLOGY

Numerous methods have been proposed in previous works for non-uniform illumination correction such as FCM algorithm and Laplace interpolation. In this paper, double thresholds had been proposed for non-uniform illumination correction. The suggested method is illustrated in Figure 1. First and foremost, the mean of the original image was calculated by using 9x9 windowing sizes. A process with a specific window size is very important in order to remain the information on the image. In this work, 9x9 pixels were used for this data set image. Second, Otsu method is adopted to get the threshold value (k) and then, set the k value as a rule to separate between low intensity (dark area) and high intensity (bright area). Based on the threshold value and proposed equation, the background was normalized. In order to evaluate the performance of the normalized image, the segmentation process was applied onto four test images.

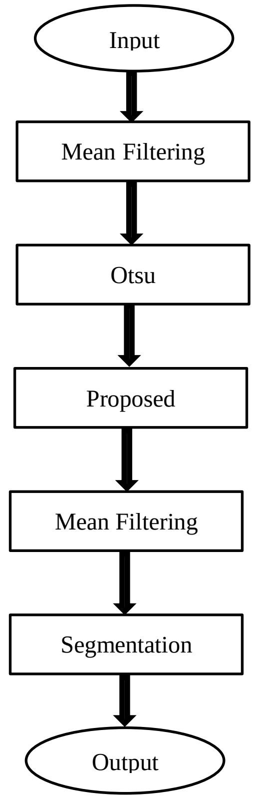


Figure 1: The flow of the proposed method

A. Mean Filter

Mean filtering is a basic and easy filter to apply for smoothing the image that focuses on the intensity of variation between one pixel and the neighbourhood pixel. It is frequently employed for blurring and noise reduction. Blurring is used in pre-processing tasks to remove small details from an image prior to the extraction of large objects, and to bridge small gaps. Noise reduction can be accomplished by smudging with a linear and non-linear filtering. In this work, a standard weighted average by 9x9 windowing size and mean filter is applied onto the original image as illustrated in Figure 2.

$$\frac{1}{81}\times\begin{bmatrix} 1 & 1 & .. & 1 \\ 1 & 1 & .. & 1 \\ : & : & : & : \\ 1 & 1 & \dots & 1 \end{bmatrix}$$

Figure 2: Weighted average

$$S = \frac{1}{81}\left[p_1 q_1 + p_2 q_2 + ...+ p_{81} q_{81}\right] \quad (1)$$

where p represents the intensity values of the original image and q as a weighted average by the 9x9 window size. By substituting the value of each pixel in an image with the average intensity in the area, an image with sharp transitions was produced. This image effectively eliminates the pixels which do not represent them. Hence, the resulting image $M(x, y)$ can be simplified as:

$$M(x,y) = \frac{1}{81} \sum_{\substack{a=0,b=0 \\ (a,b)\in S_{xy}}}^{a=81,b=81} p_{ab} q_{ab} \quad (2)$$

where (a,b) represent a window size and S_{xy} are the input image. Edges are also presented by a sharp intensity transitions; implying that the filters have unwanted side effect, which is the edges blurring effect.

B. Otsu Thresholding

Otsu thresholding is a method to segment an image between foreground and background based on the specific threshold value. However, under poor illumination and non-uniform background, it is difficult to achieve the best threshold value. Assuming that the original image has two areas: dark area and bright area denoted as C_1 and C_2, and the probability of each area, $P(s)$ is as follow:

$$P_1(s) = \sum_{i=0}^{s} P_i \quad for \quad C_1[s > 0] \quad (3)$$

$$P_2(s) = \sum_{i=s+1}^{L-1} P_i = 1 - P_1(s) \quad for \quad C_2[s+1, L-1] \quad (4)$$

where $P_1(s)$ and $P_2(s)$ are the probability for two classes of the region (C_1 and C_2), P_i represents a normalized histogram for overall image size. Besides that, in order to obtain the threshold value k under the contrast variation image, there are a few assumptions; histograms are bimodal, stationary statistics, therefore, it can be modified to become a local adaptive and uniform illumination. From this assumption, Otsu thresholding is obtained based on the following equation.

$$k = \frac{\sigma^2 B}{\sigma^2 G} \quad (5)$$

where k a threshold value, $\sigma^2 B$ is a global variance of the entire image and $\sigma^2 G$ between-class variance

C. Double Mean Value (DMV) Method

After applying the Otsu thresholding to the input image and finding the threshold value (k), two conditions have been proposed.

$$\left[M(x,y) < k\right] = \sum_{n=0}^{n=k+1} \frac{n_0 + n_1 + n_2 + ...n_{L-1}}{m \times n} \quad (6)$$

where $M(x, y)$ is the resulting image after using the mean filter with 9x9 windowing size, $n_0 + n_1 + ...n_{L-1}$ is the intensity value and $m \times n$ is the size of the image for intensity less than k value. According to the k value from Otsu, it is assumed that pixel with lower intensity than k is a dark area or unwanted area that needs to be adjusted and the intensity above than k is considered as a bright area. Thus, from the bright area, the new mean value was calculated by using 9x9 windowing size and replaced in the dark area as denoted in Equation 6. Therefore, the dark area intensity changed and the contrast variation was adjusted.

$$\left[M(x,y) > k\right] = M(x,y) \quad (7)$$

The mean value which is higher than k was assumed as a brighter area. Based on Equation 7, if $[M(x, y) > k]$, the original mean from the original image was used. Based on these two conditions, the background normalization is denoted as:

$$B(x,y) = \begin{cases} OriginalMean \ if \quad k < M(x,y) \\ NewMean \quad if \quad k > M(x,y) \end{cases} \quad (8)$$

Finally, the proposed corrected image $G(x, y)$ is calculated by using the following transformation:

$$G(x,y) = B(x,y) - I(x,y) + mean[(x,y)] \quad (9)$$

where $I(x, y)$ is the original image, $B(x, y)$ is the background normalization and $mean[(x, y)]$ is the mean value of the background. Figure 3 shows the non-uniform of original image, background normalization and the result of the proposed method along with the histogram distribution for each image. Based on the result from Figure 3, the non-uniform or contrast problem of the original image was reduced or eliminated after applying the proposed method following Equation 8 and 9. According to this figure, the original image shows the dark region at the top-left side. It is also represented by the histogram which has the intensity between 0 – 50. However, after applying proposed method, the dark region changed to become brighter and the intensity background became smooth.

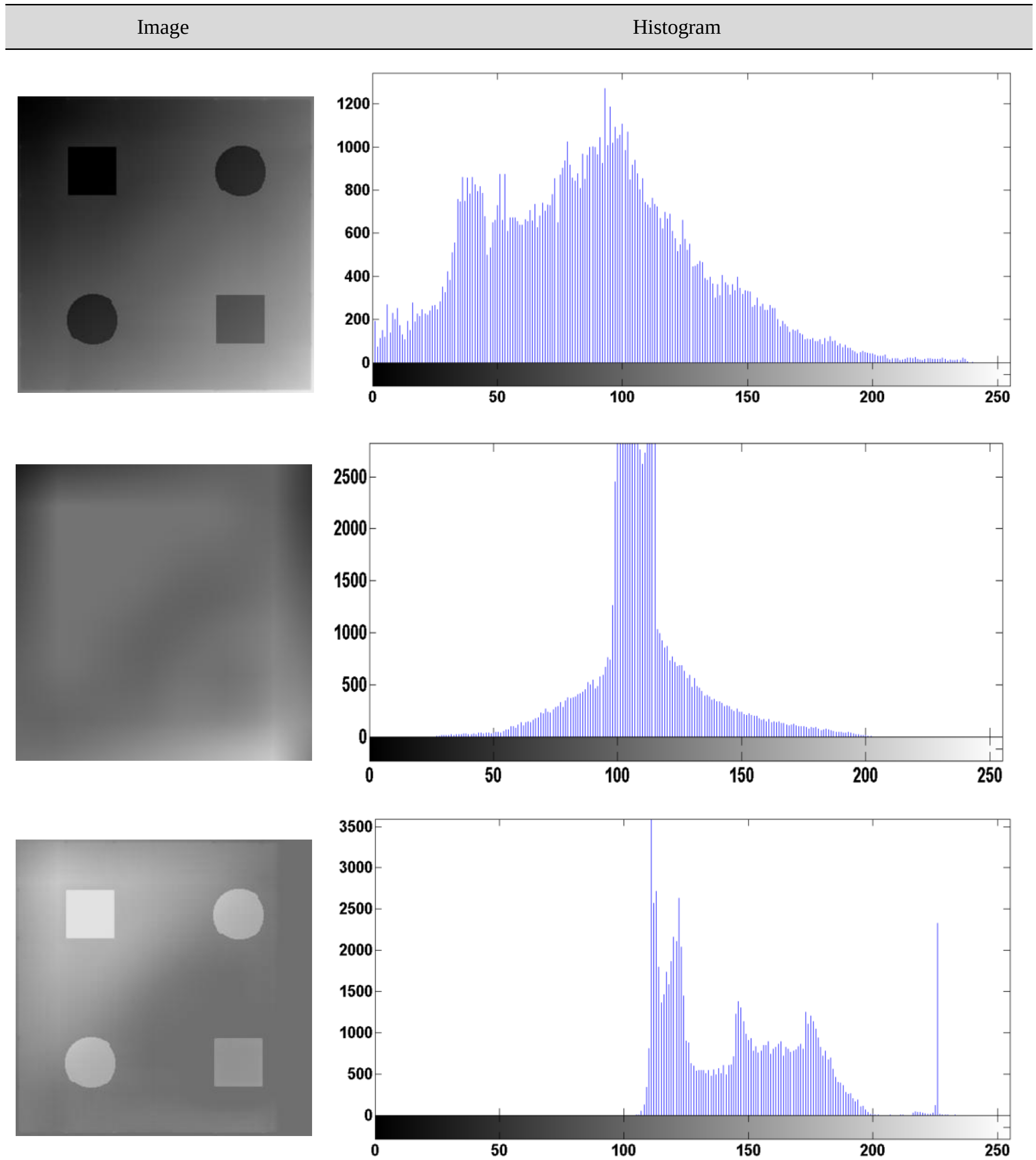


Figure 3: Comparison histogram between (a) original image, (b) background normalization and (c) corrected image

IV. RESULT

The programs were written in C programming language and Matlab R2009a and ran on Intel® Core™ i5 2.50GHz processor. Performance comparison between the proposed method and the classical segmentation method is presented in this section. In order to evaluate the image quality of the proposed method and a few other methods, the Signal Noise Ratio (SNR) is calculated as follows:

$$SNR = 10\log_{10}\left[\frac{Mean[I(x,y)]}{Std[I(x,y)]}\right] \qquad (10)$$

The SNR is defined as the contrast divided by the standard deviation of the noise. A higher SNR value indicates the contrast variation and illumination are normalized, resulting in an automatically improved image quality and vice versa. Figure 4 presents the resulting image with SNR value for the proposed method and several available methods for comparison purposes. The proposed method achieves the highest SNR which is 6.9544 compared to the low pass filter, high pass filter, and Homomorphic filtering.

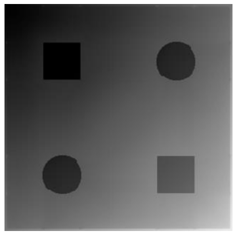
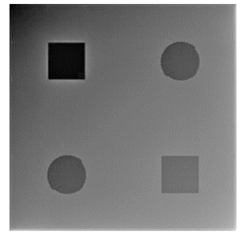
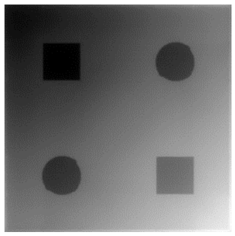
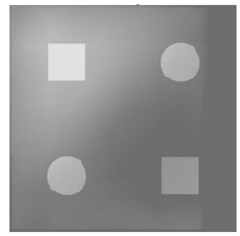
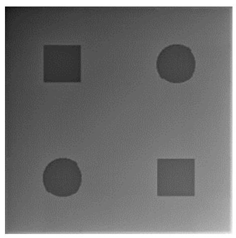
Method	Images	Signal Noise Ratio (SNR)	Method	Images	Signal Noise Ratio (SNR)
Original		3.0137	Homomorphic High Pass Filter		5.9168
Low Pass Filter		3.2333	Proposed Method		6.9544
High Pass Filter		5.7049			

Figure 4: Comparison between illumination techniques based on SNR value.

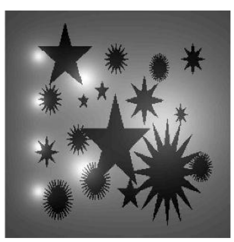
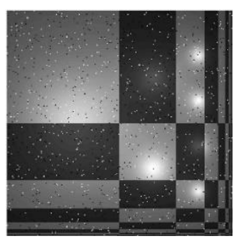
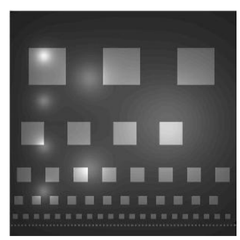
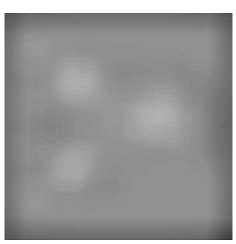
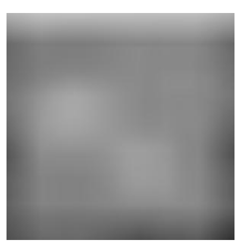
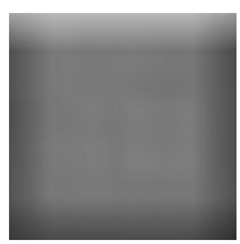
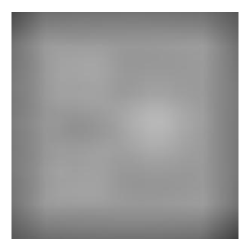
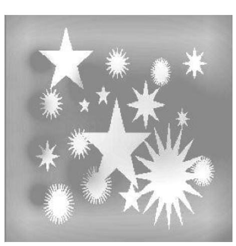
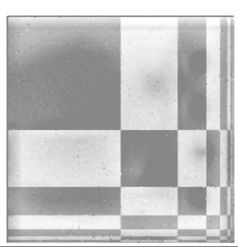
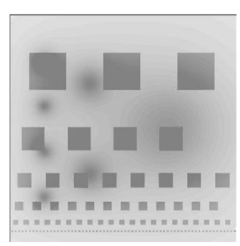
Images	Star	Rectangles	Square	Text
Original				
Proposed Background Normalization				
Proposed Image				

Figure 5: Resulting image based on the proposed method

This experimental used four (4) standard test images, namely the ‘Star’, ‘Rectangles’, ‘Square’ and ‘Text’. Figure 5 shows four (4) images which have been utilized in this work. The first row is the original image followed by the background normalization and the last row indicates the resulting image after applying the proposed background normalization method. Figure 5 illustrates that the proposed images were smooth without luminosity (noise) compared to the original image. The foreground (object) appears brighter in order to increase the efficiency of the segmentation process.

A. Segmentation process

A segmentation method is a process to convert a greyscale image into a binary image. In fact, modeling the image foreground/background is very difficult due to image degradation such as uneven illumination and image contrast variation. In this experiment, adaptive gradient based method proposed by Yazid and Arof [13] had been adopted to segment the object. In addition, the result performance is compared with six other segmentation methods, such as a Niblack’s method, Yanowitz and Bruckstein’s (YB) method, Chan’s method, Blayvas’smethod, Chen’s method and gradient based method.

Figure 6 shows the comparison between three types of segmentation method: original Otsu thresholding, proposed method incorporated with Otsu thresholding and proposed method incorporated with the gradient based method. The proposed method combining with the adaptive gradient based method produces a good result in the badly degraded image compared to the other methods. The proposed method combining with Otsu also produced a better result performance compared to the classical Otsu.

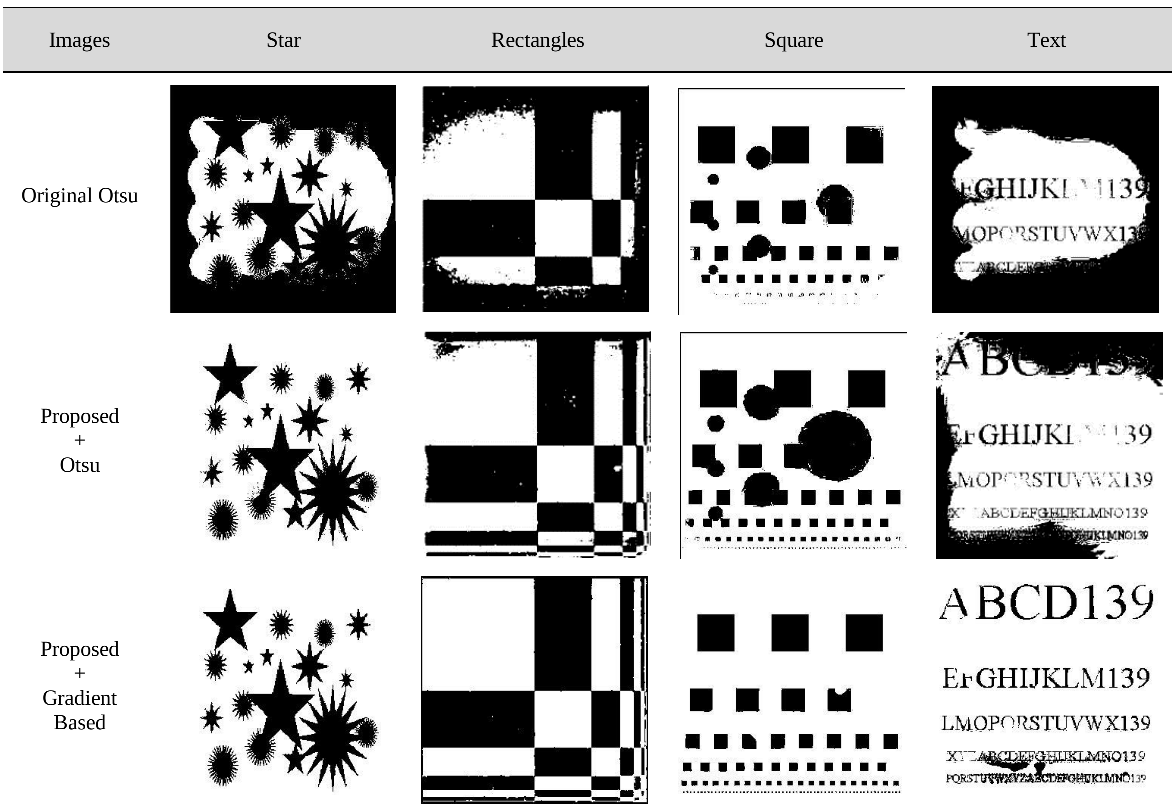


Figure 6: Segmentation results of four artificial images with simulating non-uniform illumination

B. Misclassification Error (ME)

Misclassification is defined as a variable for interpretation, analysis and leading to bias estimation if the misclassification is ignored. The misclassification error (ME) is used to evaluate the performance of the methods as depicted in Equation 11:

$$ME = 1 - \frac{|B_0 \cap B_T| + |F_0 \cap F_T|}{|B_0| + |F_0|} \qquad (11)$$

where F_0 and B_0 represent the foreground and background of the original image, while F_t and B_T is the foreground and background of the test image [14].

The ME reflects the percentages of background pixels incorrectly specified as the foreground, and conversely, the foreground pixels are not properly determined as the background. This can vary from 0 for a perfectly classified image to 1 for a totally wrong binarized image. Table 1 shows the misclassification error (ME) result compared to the six other methods.

Table 1
Misclassification error (ME) comparison between YB, Blayvas, Niblack, Chan, Chen, gradient based method and our proposed method (Double mean + Otsu thresholding and Double mean + Gradient based

Test Image	'Squares' Error	'Text' Error	'Rectangles' Error	'Star' Error
Yanowitz [15]	0.00630	0.21200	0.19100	0.31200
Blayvas [16]	0.00720	0.31200	0.07800	0.09600
Niblack [17]	0.12800	0.00000	0.15200	0.17450
Chan [18]	0.05732	0.29685	0.17340	0.17287
Chen [19]	0.00360	0.02280	0.06390	0.00030
Gradient based [20]	0.00021	0.00020	0.07915	0.00010
Double mean + Otsu	0.16751	0.24119	0.10712	0.08385
Double mean + Gradient based	0.00537	0.05872	0.05047	0.00621

Based on Table 1, the rectangles image based on our proposed method incorporated with a gradient based method overall perform better compared to the other six methods. Nevertheless, for the 'square' image, the accuracy of the proposed method segmented by gradient based is slightly higher than Chen method and gradient based method. Besides that, segmentation results for the 'text' image from proposed method is slightly lower compared to the Niblack, Chen and gradient based method, therefore it is still acceptable compared to YB, Blayvas, and Chan methods. Lastly, for the 'star' image, our proposed achieved 0.00621 is more accurate and effective compared to the other four methods: YB, Blayvas, Niblack and Chan method. According to the result for 'rectangle' image in Table 1, it shows that the proposed double mean incorporated with gradient based is effective to segment the noisy image.

V. DISCUSSION

The results of the study support that the background correction is important, especially to improve the segmentation result. Normalization with the background correction is suitable and effective in order to remain the original information on the image. The correlation between window size and segmentation is an interesting topic to be discussed. Different window size gave different effect to the segmentation result. In this paper, the window size of 9 x 9 was used. Based on the experiment, the smaller window size gave a better accuracy and effective result compared to a larger window size, especially for this dataset image. This is due to smaller window size only considered 80 neighborhood pixels to obtain the mean and standard deviation meanwhile various intensities are considered in larger window size. Various intensities may derive from the object, background or illumination/contrast. Therefore, it influences the value of the mean and standard deviation and it causes a problem to differentiate whether the window belongs to the object, background or illumination/contrast. The finding of the present study was shown by the SNR result which the proposed method is higher (6.9544) than the Homomorphic High Pass Filter (5.9168), High Pass Filter (5.7049) and Low Pass Filter (3.2333). According to Table 1, the proposed method with gradient thresholding based on Misclassification Error (ME) is achieved; (square = 0.00537, text = 0.05872, rectangle = 0.05047, star = 0.00621). In addition, the proposed method can be employed to enhance the contrast with assured brightness preservation of the image without any deterioration of visual details in different fields such as medical image, consumer electronics, video frame analysis, etc.

VI. CONCLUSION

This study has found that the illumination and contrast problem gives big effect on the segmentation process. In this paper, a new method for the background correction based on mean and Otsu value is proposed. The main contribution of this work is to normalize the non-uniform image and then segmenting the object based on the gradient based method proposed [13]. Although, it is difficult to determine the exact threshold value in the bad illumination image, the results show that the proposed method delivers a better performance compared to the few methods. The main finding of the study was summarized in table 1. In the meantime, the proposed method is effective for a noisy image. What is interesting in this paper is that the result of proposed images was segmented by Otsu showed an improved and better method than a few core segmentation methods such as Niblack, Chen, Blayyas and others. The results of this study indicate that it is very important to consider the pre-pocessing before the post processing stage. In future, the proposed method can be implemented in different applications such as handwriting recognition, non-destructive and testing and in the medical field.

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