A Tradeoff between Local and Global Thresholding Technique for Binarization of Document Image Processing

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***Abstract*—Recent expansion in image processing technology has opened new sectors in its field. Document Image Processing is one among them. The basic feature of document image is binarization of that document image. Binarization in a document image signifies the total image value is scaled into two values. A particular threshold has the decision power to binarize the image. This threshold may be local or global or adaptive. Local or adaptive thresholding always gives better result than the global method but the computation time is more. The approach of this paper is tradeoff between the computation time and the quality of the binarized image. This paper presents a modified version of global thresholding technique.**

***Index Terms*—Document Image Processing, Local and Global thresholding, Histogram, Image segmentation.**

I. Introduction

Digital storage of different document image especially historical images is essential for future as those are only in papers. Document binarization is the basic step in most document image analysis. Document Image is stored in binarized format i.e. only two levels or values are present in the image. This representation is convenient because most of the documents that occur in practice have one color for foreground (i.e. black) and a different color (i.e. white) for background. These colors are typically chosen to be high contrast difference so that the text is easily readable by humans and the computation can be easier as only two values will take part in the operation. Therefore most of the document image analysis systems have been developed to work on binary image. The real problem is faced when the documents are poor in contrast. There are many binrization techniques present in this days and more research is going on in this field.

The binarization technique is broadly classified into two types Local and Global thresholding [1,2,3,4]. Local thresholding is applied for a pixel which is in the middle of a window and based on the threshold value of the window the value of the pixel point is decided. Global threshold is for the total image i.e. one threshold value decides the values of the pixels for the total image. If one pixel value is more than the threshold value it is treated as one otherwise the value of the pixel is considered as zero. The global thresholding computes the threshold value one time only and then it decides the value for pixels to form the binary image. And the local threshold based on the threshold of a window, which decides the value of that particular pixel. Essentially the computation time will be more for local thresholding but quality wise the local thresholding technique gives better result, as the computation is done on pixel to pixel basics, than global thresholding technique.

There will not be any quality difference between local and global thresholding techniques if the image quality is fine. In practice the contrast of the image is unevenly distributed in fashion. So global thresholding techniques will not give expected quality result. In this paper it is thought to segment [5] the image so that the contrast of the image can be distributed in some appropriate manner and then apply global thresholding techniques to those segments and then join those together to form the actual document image.

The most frequent method for some of local thresholding method is Niblack [4], Sauvola [3], Bernsen [9] etc and for global thresholding method these are Otsu [1] etc. In this paper for local thresholding technique Niblack, Sauvola technique is used and for global thresholding Otsu method is used for comparison with the new technique. This technique is based upon segmenting the image and there after scale the image based on its requirement. Apply global thresholding (here Otsu method is considered) to each segment to construct a binarize image.

Rest of the paper organizes as follows sections. The basic of local and global thresholding is described in the second section. Third section explains the histogram analysis. Image segmentation and scaling is discussed in fourth section. A fifth and sixth section explain about the algorithm and shows the results and discussion. Concluding remarks presented in section seven.

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II. GLOBAL AND LOCAL THRESHOLDING

A. *Global Thresholding- Otsu method*

One well known and simple global thresholding method is Otsu thresholding method. It is based on simple finding out the threshold value which minimizes within class variance [1].

$$\sigma_w^2(t) = w_1(t)\,\sigma_1^2(t) + w_2(t)\,\sigma_2^2(t) \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Weights ω_i are the probabilities of the two classes separated by a threshold t and σ_i variances of these classes. In other words $w_1(t)$ is the probabilistic measure with gray scale levels $[1,\ldots, L_1]$ and $w_2(t)$ with gray scale levels $[L_1+1,\ldots L_n]$.

The problem with global thresholding is that it is not effective with uneven contrasted image. It is because of the variance of foreground and background is near about same in values. This illumination problem across the image can be truncated if the threshold value is taken over a small window which moves through the image i.e. to determine the threshold locally for each point of operation. Instead of having a single global threshold, it is allowed the threshold itself to vary smoothly across the image. The two well known local thresholding techniques are Niblack and Sauvola method which is described briefly in this paper.

B. *Local thresholding – Niblack and Sauvola method*

As mentioned in the previous section, one of the remedy for binarization of uneven illuminated image is local thresholding techniques. A small window decides the variance of a particular point, i.e. the pixel value of that point. Unlike global thresholding techniques, local thresholding sets new threshold value, designed from the points in the window, for each point. These methods are relay on local thresholding of Image and here the problem of unconnected pixel values is resolved. A window selects the threshold value for its center position with its mean and variance of the window. Niblack methods based on the addition and subtraction of the variance with the mean value of the operating window and Sauvola method is based on the multiplication and division with the mean.

The threshold rule for Niblack for a point is

Threshold= mean + k * standard deviation -*c*

The value of k is 0.2 for bright objects and -0.2 for dark objects. The default value of *c* is zero. It can be changed to any other value according to operation.

The threshold rule for Sauvola for a point is

Threshold= mean * (1+ k * (standard deviation / -r -1))

K and r is the constant. Both of this technique computes the threshold over a small window compare to the image

III. IMAGE HISTOGRAM ANALYSIS

Histogram plot gives the tonal distribution of an image. It measures the frequency of occurrence of a value. In general this is a graphical representation for the distribution of pixel values in a image. The horizontal axis represents the value for a pixel (i.e. brightness or contrast) and the vertical axis shows the occurrence of number of pixel for a particular value of the image.

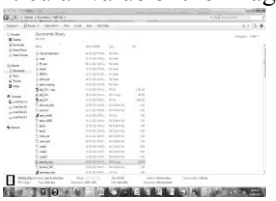

Figure 1.a

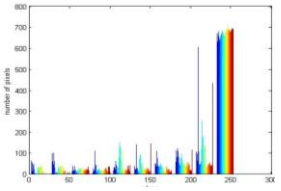

Figure 1.b

Figure 1.a shows a gray scaled image and Figure 1.b describes its histrogram value. As the background is covered by most number of pixel, it can be seen the maximum number of pixel is accumulated in the maximum value of the histrogram plot. The other points have diffrent number of pixel frequencies.

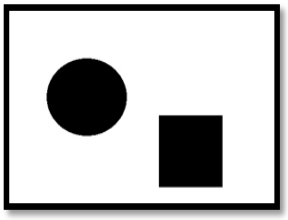

Figure 2.a

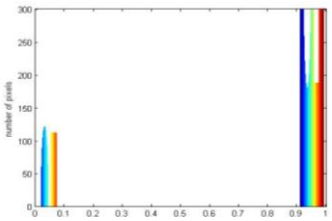

Figure 2.b

Figure 2.a shows a binary iamge which has two values in the image. So from the defination of histogram it can be concluded that the histogram of this iamge consist of two values. Figure 2.b explain the histogram plot for the binary image Figure 2.b.

The Otsu method defines a global threshod for an image which partioned its pixels to two diffrent segment. In this example for Figure 1.a, the threshold value computed is 176. It means the pixel values more than this threshold level goes to foreground and if it is less that goes to background.

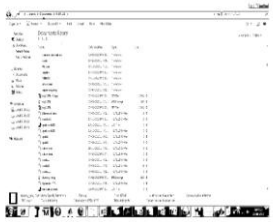

Figure 3.a

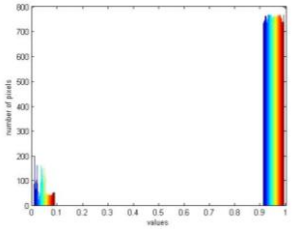

Figure 3.b

Figure 3.a shows the binarized image of Figure1.a and Figure 3.b shows the histogram plot for this binarized image which describes only the two levels for the image.

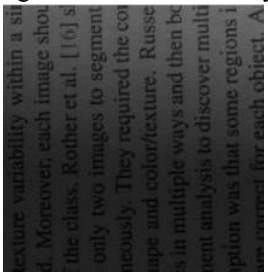

Figure 4.a

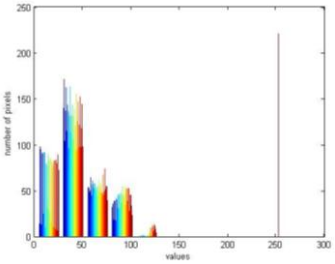

Figure 4.b

Figure 4.a displays an uneven contrasted image and the

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histogram displays so. Due to low contrast the density of the histogram is nearer to low value. Direct global thresholding cannot produce proper binarized image in this case because of the global threshold value would not be proper for every portion of the image.

IV. Segmentation and Scaling

Image is the collection of pixels or in other words it is a static signal. There is a provision to split the image in several parts and then again tie those to construct the basic image. Those segmented portions can be operated separately to fight the unevenness of the image. This segmentation property has been taken in to account for this problem.

Improper illumination creates irregular distribution of light in the document image. This results uneven contrasted image. The crisis of this improper distribution can be resolved if the image is scaled properly. The approach which is taken over here is based on the mean of the total image to the maximum level value. It is a mapping between the mean to maximum value of the scale. Let the mean value of the image (or the segment of the image) is 2^M and maximum value of the mapping is 2^N. The scaling factor is computed, in this work, as $2^N/2^M$. This multiplication changes the gray scaling of the image. The values which were near about to each other gets some extra space after the multiplication. Addition of some constant is introduced based on Nibalck process which is not point computing process rather it is based upon the mean of the image and the constant is added or subtracted to the total image. It means the variance of the image changes. From Otsu [1] method discussion it can be said that the global threshold for the image is also gets changes and gives more effective results. This multiplication cannot be directly applied to an image, because of unevenness of the light distribution.

As the aim of this work is a tradeoff between local and global thresholding process, segmentation is done and then the above discussed technique is applied to the image for scaling to find out the suitable global threshold to convert the image to a binary image.

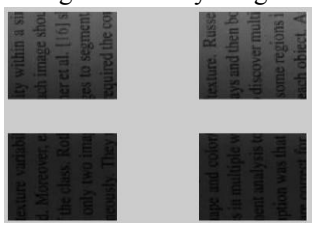

Figure 5.a

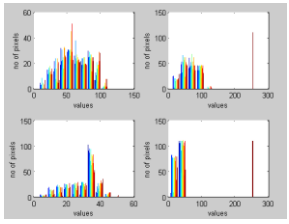

Figure 5.b

Figure 5.a is the sliced image and Figure 5.b shows the histogram of each block. If the histogram plot of Figure 4.b and Figure 5.b is compared it can be easily visible the distribution is not now concentrated on a particular portion. Here after splitting scaling is done to distribute the values of the image more appropriately.

Figure 6.a

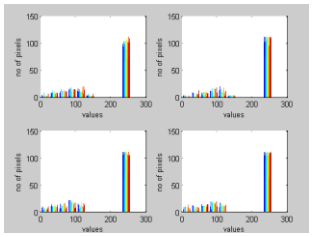

Figure 6.b

Figure 6.a and Figure 6.b represents the scaled image and their respective histograms. The mean for different segment is different, so after the multiplication the all segmented blocks are mapped to a particular value (here standard gray scale value i.e. 255 is taken). The histogram comparison of Figure 5.b and Figure 6.b states that the proper scaled has been done and the variance difference is more for foreground and background.

V. Algorithm

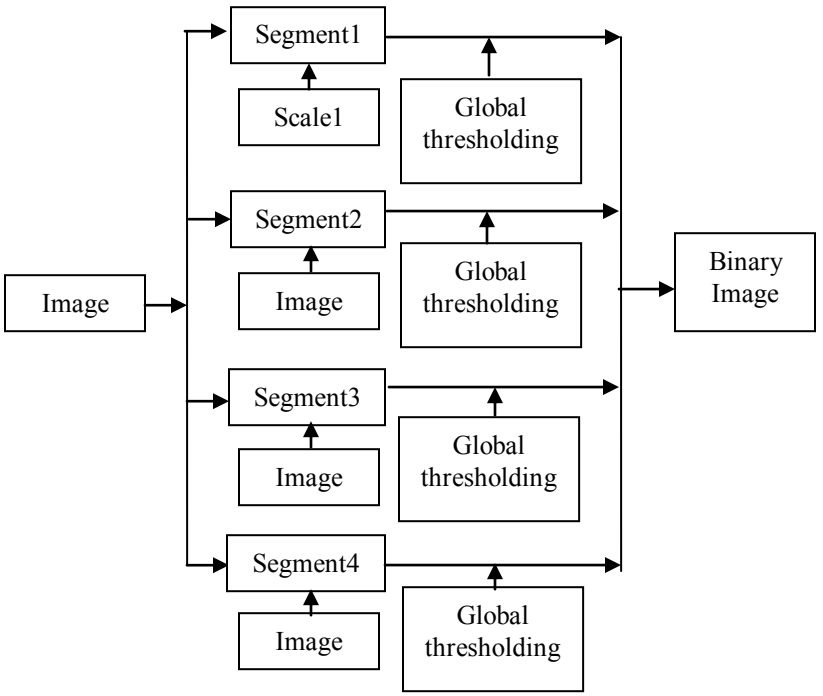

Figure 7 the flowchart of this process

The process followed in the paper is described in this flowchart. The image is segmented and scaled which is discussed in the previous section. The global thresholding technique is applied then to those segmented image. The segments will from respective binary image. Those binarized images are tied together to obtain the actual binarized image.

VI. Results and Discussion

The scaled segmented image is binarized using otsus method.

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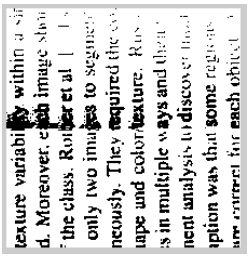

Figure 8.a the output result by this method

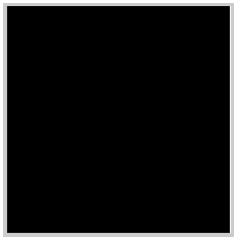

Figure8.b applied Otsu method directly

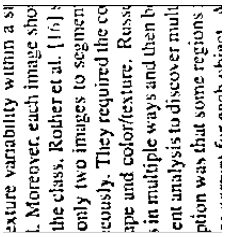

Figure 8.c output Niblack method

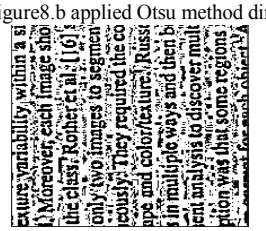

Figure 8.d output Sauvola method

The above images show the comparison between local and global thresholding method. It can be seen the quality of the image is better when local thresholding (Niblack and Sauvola) is used.

Otsu's method	Sauvola's method	NiBlack's method	Modified global thresholding method
0.3906	8.3281	11.5469	0.4375

Table 1 Time comparison among the binarization methods (in seconds)

Table1 contains the measurement of the computation time of binarization for the Figure 4.a. The time taken by Otsu method is minimum. For NiBlack it is maximum and for Sauvola method the time taken is also high. Compared to these results the modified global thresholding technique takes little time more than the global thresholding method. Computation time wise it is very much effective than the local thresholding method.

Another parameter taken in account for evaluating this method is PSNR (peak signal to noise ratio). It is a comparison between the actual and computed image.

Otsu's method	Sauvola's method	NiBlack's method	Modified global thresholding method
19.7035	21.1621	21.6121	20.6321

Table 2.2 PSNR comparison among the binarization methods

Aim of this work is a tradeoff between local and global thresholding for binarization of an image. From the above results and comparisons it is evident that the tradeoff is successful.

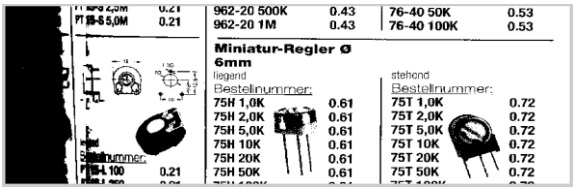

Figure 9.a

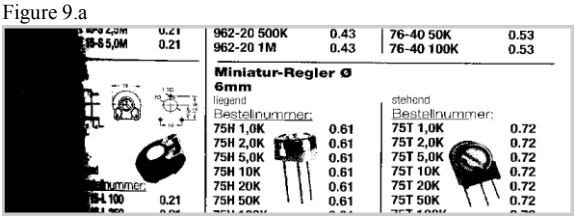

Figure 9.b

Figure 9.c

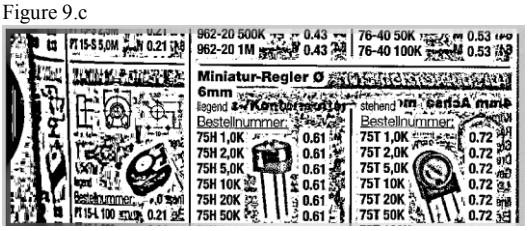

Figure 9.d

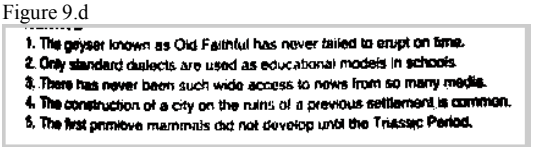

Figure 10.a

Figure 10.b

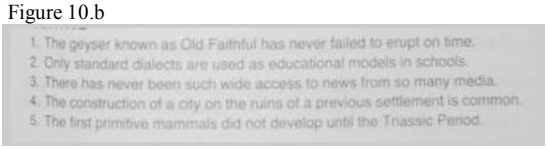

Figure 10.c

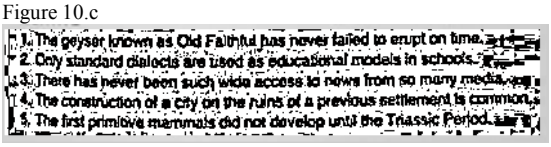

Figure 10.d

Figure 9.a and 10.a is the output when global thresholding is applied on segmented and scaled version of figure 9.c and 10.c respectively, where as 9.b and 10b is direct global threshold applied value on image Figure 9.c and 10.c respectively.Figure 9.d and 10.d is the local thresholded output of figure 9.c and 10.c. respectively.

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VII. CONCLUSION

The proposed technique is defines how the quality and time to get that quality can be negotiable using global thresholding. The segmentation and operation is one form of local threshold processing. The difference which defines the work is segmentation in few parts and scale and binarized the image. Briefly the work feature is

- Less computation time than local thresholding process.
- PSNR is high.
- The quality is better than other global thresholded process.
- The segmentation can be more in case of a large image.

Though this work can be improved more by

- Choosing the segments properly.
- Find a new way to scale the image.
- The image quality is not good as local thresholding process.

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