Adaptive Local Image Contrast in Image Binarization

Prof.Sushilkumar N Holambe. PG Coordinator ME(CSE) ,College of Engineering, Osmanabad
Dr.Ulhas B Shinde.Principal,Chh.Shahu College of Engineering,Aurangabad
Bhagyashree S Choudhari. PursuingME(CSE), College of Engineering, Osmanabad

Abstract— Image binarization is the process of separation of image pixel values as background and as a foreground. We set white pixels as background and black pixels as a foreground. It firstly convert the degraded document image into gray scale document image and then in to binary document image. To perform such a segmentation of document image into background and as a foreground Most of the binarization techniques consider the intensity values associated with pixels. To distinguish these intensity values we will consider one intensity value called threshold. Each and every pixel of the gray scale images compared with the threshold value and according to that pixels are separated as background pixel and foreground pixel. Thus selection of threshold value is important for the separation

Index Terms— Adaptive image contrast, Contrast Image, degraded image, image binarization, local contrast, document analysis, document image processing, image gradient, Local maxima and minima.

———————————— ◆ ————————————

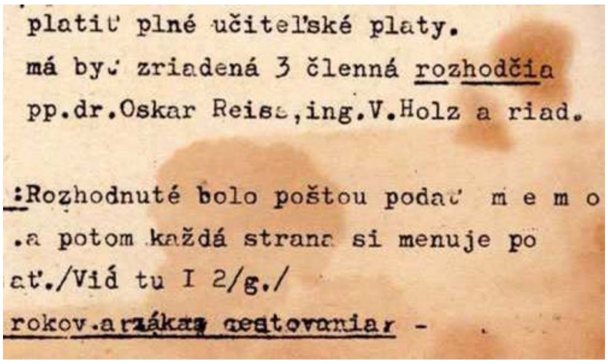
Abstract : *Image binarization is the process of separation of image pixel values as background and as a foreground. We set white pixels as background and black pixels as a foreground. It firstly convert the degraded document image into gray scale document image and then in to binary document image. To perform such a segmentation of document image into background and as a foreground Most of the binarization techniques consider the intensity values associated with pixels. To distinguish these intensity values we will consider one intensity value called threshold. Each and every pixel of the gray scale images compared with the threshold value and according to that pixels are separated as background pixel and foreground pixel. Thus selection of threshold value is important for the separation*

Keywords - *Adaptive image contrast, Contrast Image, degraded image, image binarization, local contrast, document analysis, document image processing, image gradient, Local maxima and minima.*

1. INTRODUCTION

Preprocessing stage in the degraded document image processing is the document image binarization. Image binarization is the mostly used in document analysis process & in OCR related applications. To deal with the cases where recognizing or improving the text from badly degraded or historical documents is necessary. In such applications conversation of document image in to binary form is preferable. To remove some of these artifacts from historical or degraded documents and to recover the original image segmentation through thresholding is needed. The degraded Historical documents are shown in fig.1

ISSN 2229-5518


platiť plné učiteľské platy.
má byť zriadená 3 členná rozhodčia
pp.dr.Oskar Reiss,ing.V.Holz a riad.

:Rozhodnuté bolo poštou podať m e m o
.a potom každá strana si menuje po
ať./Viď tu I 2/g./
rokov.a zákaz cestovania -

Fig1: Example of Degraded historical document

2. TYPES OF THRESHOLDING

Major types of thresholding are:

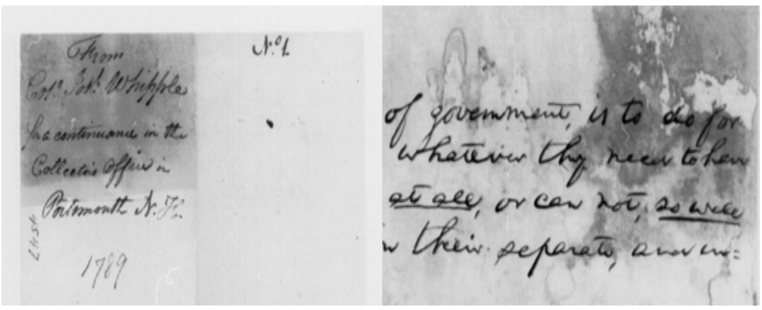
1. Global thresholding
2. Local or adaptive thresholding

2.1 Global thresholding

When single threshold for the whole document is used in the binarization techniques it is called as global thresholding .Otsu'smethod [1] is one of the famous global thresholding methods, which is a histogram shape-based image thresholding technique. Global thresholding is useful in the applications where images have uniform contrast distribution of background and foreground .Global thresholding is not suitable where changes in illumination across the scene may cause some parts to be lighter (in the light) and some parts darker (in shadow) in ways that have nothing to do with the objects in the image. To deal with such situation of uneven illumination we need to determine the thresholds locally. That is, instead of having a single global threshold, we allow the varying threshold smoothly across the image

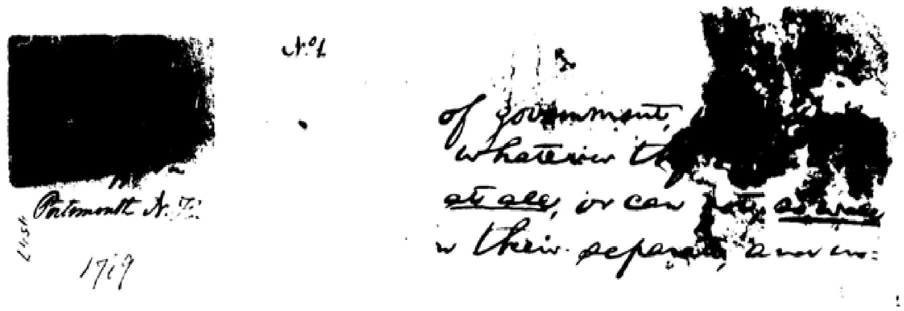
If *g(x,y)* is a thresholded version of *f*(*x*, *y*) at some global threshold *T*,

$$g(x,y)=\begin{cases} 1 & if \;\; f(x,y) \geq T \\ 0 & otherwise \end{cases} \quad \ldots\ldots\ldots\ldots(1)$$



(a) (b)

Fig.2 Degraded document image (a),(b) examples, taken from (DIBCO) dataset



(a) (b)

Fig.3.Binarization Results: using Otsu's method of images (a),(b) in Figure 2

2.2 Local or adaptive thresholding

The local binarization techniques find a threshold for each pixel inthe document imageA threshold T(x,y) is a value such that,

$$b(x,y)=\begin{cases} 0 \ if \ \ I(x,y) \le T(x,y) \\ 1 \ \ otherwise \end{cases} \quad \text{……….(2)}$$

Calculation of threshold in local adaptive technique is based on some local statistics such as variance, range or surface-fitting parameters of the neighborhood pixels. Threshold calculation can be performed in different ways such as background subtraction [2], water flow model [3], mean and standard derivation of pixel values [4], and local image contrast [5].

Though local thresholding is suitable in applications with degraded documents there are some drawbacks of the local thresholding techniques as it is individual image characteristics, region size dependant, and time consuming due to its locally threshold calculation. Using of both local and global methods [6] combineknown as hybrid approach is preferable by many researchers. Another approaches in use are morphological operators [7].local variance techniques are used by Niblack [9], and Sauvola and Pietaksinen [7] whileBernsen[8] uses midrange value within the local block.

2.2.1. Local variance methods

Niblack [9], and Sauvola and Pietaksinen [4] use the local variance technique. In these methods, the threshold is calculated based on the local mean $\boldsymbol{m(x,y)}$ and standard deviation $\delta\boldsymbol{(x,y)}$ within a window of size $\boldsymbol{w \times w}$. Sauvola and Pietaksinen's method is an improvement on the Niblack'smethod, especially for stained and badly illuminated documents

2.2.1.1 Niblack's Technique

In this method the local threshold value $\boldsymbol{T(x,y)}$ at $(\boldsymbol{x,y})$ is calculated within a window of size $\boldsymbol{w \times w}$ as :

$$T(x,y)=m(x,y)+k\,\delta(x,y) \qquad \text{…………(3)}$$

Where,

$m(x,y)$=local mean

δ(*x,y*)=standard deviation

k=bias

This local mean & standard deviation are for the pixels inside the local window. The result is satisfactory at ***k* = -0.2** and ***w=15***. According to the contrast in the local neighborhood of the pixel, the threshold values are adapted by local mean ***m*(*x,y*)** and standard deviation δ**(*x,y*)**.The bias ***k*** controls the level of adaptation varying the threshold value.

2.2.1.2 Sauvola's Technique

In Sauvola's binarization method, the threshold ***T*(*x,y*)** is expressed as:

$$T(x,y)=m(x,y)\left[1+k\left(\frac{\delta(x,y)}{R}-1\right)\right] \qquad \text{……………..(4)}$$

The calculation of thresholdld***T*(*x,y*)** is done using the mean ***m*(*x,y*)** and standard deviation δ***(x,y)*** of the pixels within a window of size ***w***×***w***.where R is the maximum value of the standard deviation (R = 128 for a gray scale document), and ***k*** is a bias, which takes positive values in the range [0.2, 0.5]. According to the contrast in the local neighborhood of the pixel, the threshold values are adapted by local mean ***m*(*x,y*)** and standard deviation δ**(*x,y*)**.When there is some region of the image with high contrast,***s*(*x,y*) ~ R** which, results in ***T*(*x,y*) ~ *m*(*x,y*).**

This result is same as that of Niblack's method. However, the difference comes in when the contrast in the local neighborhood is quite low. In that case the threshold ***T*(*x,y*)** goes below the mean value thereby successfully removing the relatively dark regions of the background.

Controlling the value of the threshold in local window is done the parameter ***k,as***higher the value of ***k***, the lower the threshold from the local mean***m*(*x,y*)**. However in order to compute the threshold ***T*(*x,y*)**, local mean and standard deviation have to be computed for each pixel. Computation of ***m*(*x,y*)** and δ**(*x,y*)** in a naive way results in a computational complexity of O ($n^2 \times w^2$) for the image of size $n \times n$

2.2.2. Local gray range method

The local gray range technique is used by J.Bernsen [8]. Threshold value determination is done by the range between the minimum and maximum pixel gray range within the local window.

ISSN 2229-5518

2.2.2.1 Bernsen's Technique:

In this method the local threshold value ***T(x,y)*** at ***(x,y)*** is calculated within a window of size *w*×*w* as:

$$T(x,y)=\left(\frac{I\max(i,j)-I\min(x,y)}{2}\right)\ldots\ldots\ldots\ldots..(5)$$

Where *Imax* and *Imin* are maximum and minimum gray values within the local window ,and it will provide the contrast as,

C(i,j)=Imax(.i,j)-Imin(i,j)……………………..(6)

In this method, the threshold is set at the midrange value, which is the mean of the maximum and minimum gray values in a local window of size ***w×w***. *to achieve a satisfactory result* A value of ***w is set at* 31.** However, if the contrast *C*(***i,j***) is below a certain threshold value, the pixel is set as background directly. Otherwise depending upon the value of T(x,y), pixel will beclassified in to background or text. There is no bias to control the threshold value.

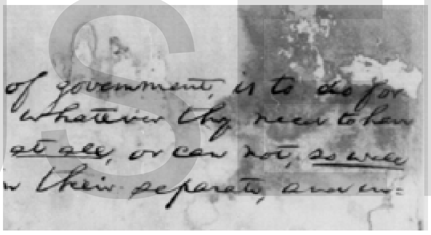
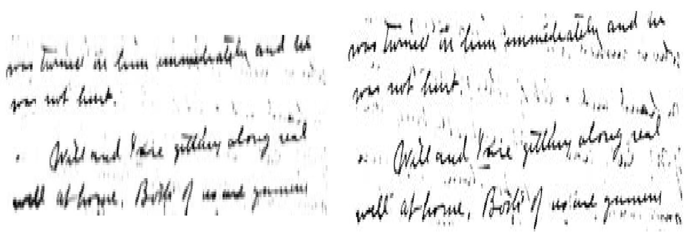


Fig4: Degraded document image example taken from DIBCO dataset series and Bickley diary dataset.



(a) (b)

(c) (d)

Fig5: Binarization Results of the sample document image in Figure 4 produced by different methods:(a) Otsu's method, (b)Niblack's method, (c) Sauvola's method,(d) Bernsen's method

3. LIMITATIONS OF DIFFERENT SYSTEMS

3.1 Window-based adaptive thresholding techniques: Window-based adaptive thresholding technique was used early, [10], [11] may estimate the local threshold by using the mean and the standard variation of image pixels within a local neighborhood window. But it will introduce one drawback as working with this thresholding techniques, the thresholding performance depends heavily on the window size and hence the character stroke width.

3.2 Bernsen's method: Bernsen's method works on the principal of local contrast as shown in equation 6 is simple, but cannot work properly on degraded document images with a complex document background.

3.3 Novel document image binarization method: Novel document image binarization method [12] by using the local image contrast is introduced to overcome the problem of Bernsen's method. And the local image contrast is evaluated as follows[13]:

$$C(x,y)=\left(\frac{I\max(i,j)-I\min(x,y)}{.I\max(i,j)+I\min(i,j)+\in}\right)\text{.............}(7)$$

Where, $\in$ is a positive but infinitely small number that is added in case the local maximum is equal to 0.

The local maximum and minimum method as per Equation 7, introduces a normalization factor (the denominator) to compensate the image variation within the document background. Text within shaded document areas of document image in, small image contrast around the text stroke edges in Equation 6(resulting from the shading) will be compensated by a small normalization factor (due to the dark document background) as defined in Equation 7. For image pixels within bright regions, it will produce a large normalization factor to neutralize the numerator and accordingly result in a relatively low image contrast. For the image pixels within dark regions, it will produce a small denominator and accordingly result in a relatively high image contrast.

One of the limitation of this the local maximum and minimum method is that it may not handle document images with the bright text property. This is because a weak contrast will be calculated for stroke edges of the bright text where the denominator in Equation 6 will be large but the numerator will be small.

- Adaptive local image contrast method: To overcome the over-normalization problem of the local maximum and minimum method, we combine the local image contrast with the local image gradient and derive an adaptive local image contrast as follows:

$$C\alpha(i,j) = \alpha C(i,j) + (1-\alpha)(I\max(i,j) - I\min(i,j)) \quad \text{…………..} \ (8)$$

where C(i, j) denotes the local contrast in Equation 6 and (Imax(i, j) − Imin(i, j)) refers to the local image gradient that is normalized to [0, 1]. The local windows size is set to 3 empirically. α is the weight between local contrast and local gradient and based on the document image statistical information, it is controlled. Ideally, the image contrast will be assigned with a high weight (i.e. large α) when the document image has significant intensity variation. So that the proposed binarization technique depends more on the local image contrast that can capture the intensity variation well and hence produce good results. Otherwise, the local image gradient will be assigned with a high weight. The proposed binarization technique relies more on image gradient.

3. CONCLUSION

This paper proposes a new Adaptive local image contrast thresholding technique, which will combine the local image contrast and local image gradient. Using this method will overcome the over-normalization problem of local maxima and minima.The proposed technique is compared with other relevant methods and found to be better than other contemporary methods, both in terms of quality and speed.

REFERENCES

[1] N. Otsu, “A threshold selection method from gray level histogram,” *IEEE Transactions on System, Man, Cybernetics, vol. 19,* no. 1, pp. 62–66, January 1978.

[2] B. Su, S. Lu, and C. L. Tan, “Document Image Binarization Using Background Estimation and Stroke Edges,” *Proc. Intl. Journal on Document Analysis &Recognition, Vol. 13,* No. 4, pp. 303-314, 2010.

[3] O. H. Hwa, L. T. Kil, and C. I. Sung, “An Improved Binarization Algorithm Based on a Water Flow Model for Document Image with Inhomogeneous Backgrounds,” *Pattern Recognition, Vol. 38,* pp. 2612 –2625, 2005.

[4] J. Sauvola and M. Pietikainen, “Adaptive document image binarization,” *Pattern Recognition 33(2),* pp. 225–236, 2000.

[5] O. H. Hwa, L. T. Kil, and C. I. Sung, “An Improved Binarization Algorithm Based on a Water Flow Model for Document Image with Inhomogeneous Backgrounds,” *Pattern Recognition, Vol. 38,* pp. 2612 –2625, 2005.

[6] B. Gatos, I. Pratikakis, and S. J. Perantonis, "Adaptive Degraded Document Image Binarization," *Pattern Recognition, Vol. 39*, No. 3, pp. 317–327, March 2006.

[7] T.HoangNgan Le, Tien D. Bui, and Ching Y. suen, "Ternary Entropy – based Binarisation of Degraded Document Images Using Morphological Operators" 1520-5363/11$26.00 ©2011 IEEE.

[8] Bernsen, J.: 'Dynamic thresholding of gray-level images'. Proc. 8th Int. Conf. on *Pattern Recognition*, Paris, 1986, pp. 1251–1255

9] Niblack, W.: 'An introduction to digital image processing' (Prentice- Hall, Englewood Cliffs, NJ, 1986), pp. 115–116

[10] J. Sauvola and M. Pietikainen, "Adaptive document image binarization," *Pattern Recognit., vol. 33,* no. 2, pp. 225–236, 2000.

[11] W. Niblack, An Introduction to Digital Image Processing. Englewood Cliffs, NJ: Prentice-Hall, 1986.

.

[12] B. Su, S. Lu, and C. L. Tan, "Binarization of historical handwritten document images using local maximum and minimum filter," in Proc.Int. Workshop Document Anal. Syst., Jun. 2010, pp. 159–166.

[13] M. van Herk, "A fast algorithm for local minimum and maximum filters on rectangular and octagonal kernels," *Pattern Recognit.Lett., vol. 13*, no. 7, pp. 517–521, Jul. 1992.