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EVLOUTINARY METHODOLOGY FOR IMAGE DOCUMENT BIDIRECTIONAL TECHNIQUES

[#1]BIRADAR GEETA -M.Tech Pursuing,
[#2]MADDURU SAMBASIVUDU-Asst.Professor,
Department of Computer Science & Engineering,
Malla Reddy College Of Engineering & Technology, Hyderabad.

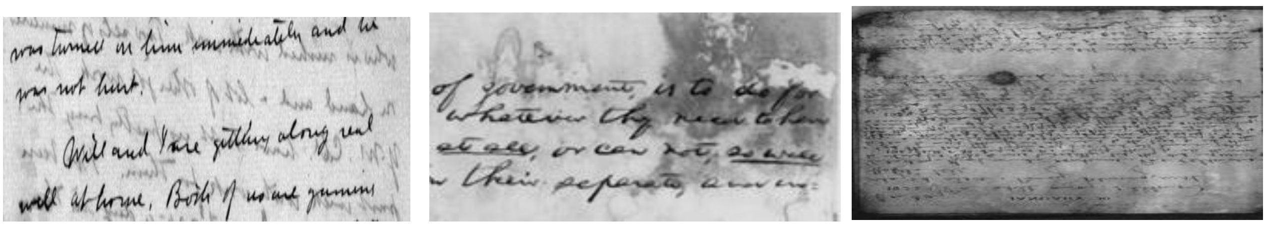
Abstract— Document Image Binarization converts a gray-scale document image into binary document image .It is usually performed in the pre-processing stage of document image analysis and it aims to segment the foreground text from the document background. Segmentation of foreground text from the document background is a difficult task in the case of degraded document images. In this paper we propose a simple and efficient document image binarization technique which is able to produce good results for badly degraded document image. It makes use of an Improved Adaptive Image Contrast .Adaptive Image Contrast combines the local image contrast and local image gradient adaptively. In the proposed technique, input degraded document image is first normalized to make contrast image enhancement easier. Then an adaptive image contrast map is constructed for the normalized input image.Second.Contrast image enhancement is performed.Third,Contrast map is binarized and combined with Canny's edge map to detect the text stroke edge pixels accurately.Finally,the document text is extracted by a local threshold that is estimated based on the intensities of the detected text stroke edge pixels. This technique requires only minimum number of parameters. It has been tested on various images in DIBCO dataset and Bickley diary dataset and achieves high accuracies interms of various performance measures.

Keywords—Document Image Processing, Document Image binarization, Degraded document image, Adaptive Image Contrast

I. INTRODUCTION

Image binarization converts an image of up to 256 gray levels to a black and white image. Frequently, binarization is used as a pre-processor before Optical Character Recognition (OCR). Document image binarization converts a gray-scale document image into a binary document image and it aims to segment the foreground text from the document document background. Segmentation of a text from a badly degraded document image is a difficult task due to variations in the document image properties. Degradation means every sort of less-than-ideal properties of a real document image, for example smear, bleed-through, geometric deformations etc.

This paper presents an improved adaptive image contrast based document image binarization technique that extends the previous document image binarization technique based on adaptive image contrast. In particular, proposed technique addresses the over-binarization problem of the previous technique based on adaptive image contrast. Adaptive image contrast is a combination of the local image contrast and the local image gradient. Here input document image is first normalized to make contrast image enhancement easier .Contrast image enhancement aims to improve the visual appearance of the image or to provide a better transform representation for future segmentation of text from the document image. Enhanced contrast image map is then binarized and combined with canny's edge map to detect text stroke edge pixels accurately. Finally, the document text is extracted by a local threshold that is estimated based on the intensities of the detected text stroke edge pixels.



(a) (b) (c)

Fig 1.Three degraded document image examples (a) and (b) are taken from DIBCO series datasets and (c) is taken from Bickley diary dataset

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II. RELATED WORK

Though document image binarization has been studied for many years, the thresholding of degraded document images is still an unsolved problem due to the high inter/intra-variation between the text stroke and the document background of the different document images. The handwritten text within the degraded documents often shows a certain amount of variation in terms of the stroke brightness, stroke connection, stroke width, and document background. In addition, historical documents are usually degraded by the bleed through where the ink of the other side seeps through to the front. These different types of document degradations tend to generate the document thresholding error and make degraded document image binarization a big challenge to most state-of-the-art techniques.

Document image binarization plays a key role in document processing since its performance affects quite critically the degree of success in subsequent character segmentation and recognition. In general, approaches that deal with document image binarization are categorized in two main classes: (i) global and (ii) local. In a global approach, threshold selection results in a single threshold value for the entire image. Global thresholding [2, 10, 15] has a good performance in the case that there is a good separation between the foreground and the background. However, in the case of degradations (e.g. shadows and non-uniform illumination, ink seeping) the current trend is to use local information that guides the threshold value pixel wise in an adaptive manner. Adaptive thresholding [1, 6, 9, 16, 17, 14, 19], which estimates a local threshold for each document image pixel, is often a better approach to deal with different variations within degraded document images.

For example, the early window based adaptive thresholding techniques [17, 14] estimate the local threshold by using the mean and the standard variation of image pixels within a local neighbourhood window. The main drawback of this window-based thresholding approach is that the thresholding performance depends heavily on the window size and hence the character stroke width. Other approaches have also been reported to binarize historical document images through background subtraction [13, 8], texture analysis [12], decomposition method [4], morphological operations [11], shape based local thresholding [7], classification framework [20], and cross section sequence graph analysis [5], and so on. These approaches combine different types of image information and domain knowledge and are often complex and time consuming.

The local image contrast and the local image gradient are very useful features for segmenting the text from the document background because the document text usually has certain image contrast to the neighbouring document background. They are very effective and have been used in many document image binarization techniques [3], [1], [17], [14]. In Bernsen's paper [1], the local contrast is defined as follows:

$$C(i,j) = f_{\max}(i,j) - f_{\min}(i,j) \qquad (1)$$

where *C(i, j)* denotes the contrast of an image pixel *(i, j)*, $f_{\max}(i,j)$ and $f_{\min}(i,j)$ denote the maximum and minimum intensities within a local neighbourhood windows of *(i, j)*, respectively. If the local contrast *C(i, j)* is smaller than a threshold, the pixel is set as background directly. Otherwise it will be classified into text or background by comparing with the mean of $f_{\max}(i,j)$ and $f_{\min}(i,j)$. Bernsen's method is simple, but cannot work properly on degraded document images with a complex document background. There is an earlier document image binarization method [3] by using the local image contrast that is evaluated as follows:

$$C(i,j) = \frac{f_{\max}(i,j) - f_{\min}(i,j)}{f_{\max}(i,j) + f_{\min}(i,j) + \varepsilon} \qquad (2)$$

where ε is a positive but infinitely small number that is added in case the local maximum is equal to 0.

Compared with Bernsen's contrast in Equation 1, the local image contrast in Equation 2 introduces a normalization factor (the denominator) to compensate the image variation within the document background. However, the image contrast in Equation 2 has one typical limitation that it may not handle document images with the bright text properly. This is because a weak contrast will be calculated for stroke edges of the bright text where the denominator in Equation 2 will be large but the numerator will be small. To overcome this over-normalization problem, the local image contrast is combined with the local image gradient and derives an adaptive local image contrast [18] as follows:

$$C_a(i,j) = \alpha C(i.j) + (1-\alpha)(f_{\max}(i,j) - f_{\min}(i,j)) \quad (3)$$

where *C(i,j)* denotes the local contrast and $(f_{\max}(i,j) - f_{\min}(i,j))$ refers to the local image gradientthat is normalized to [0, 1]. The local windows size is set to 3 empirically and *α* is the weight between local contrast and local gradient that is controlled based on the document image statistical information.

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III. PROPOSED METHOD

This section describes the proposed document image binarization technique. A degraded document image is given, first input degraded document image is normalized then an adaptive image contrast map is constructed for the normalized input image.Second.Contrast image enhancement is performed. Third, Contrast map is binarized and combined with Canny's edge map to detect the text stroke edge pixels accurately. Finally, the text is extracted from the document background by a local threshold that is estimated based on the intensities of the detected text stroke edge pixels.

A. Contrast Image Construction

The main aim of the contrast image construction is to detect the text stroke edge pixels properly. In prior to the construction of the adaptive image contrast map given input degraded document image is noramlized.In image processing normalization is process that changes the range of pixel intensity values. The main purpose of the normalization is to bring the image into a range that is more familiar or normal to the senses, hence the term normalization.

Next step is to create a proper contrast image for the normalized input image. For that, we combine local image contrast with local image gradient adaptively and derive an adaptive image contrast as follows.

$C_a (i,j)=□C(i,j)+(1-□)(I_{max}(i, j)- I_{min}(i, j))$

where C(i, j) denotes the local contrast of image pixel (i,j) ,$C(i,j)=(I_{max}(i\ j)- I_{min}(i, j))/(I_{max} (i,j)+I_{min} (i,j))+\varepsilon$

I_{max} (i, j) and I_{min} (i, j) denote the maximum and minimum intensities within a local neighborhood windows of (i, j) respectively. Where ε is a infinitely positive small number that is added in case the local maximum is equal to 0.□ is the weight between local image contrast and local image gradient and the value of □ is computed using □= $(std/128)^{\gamma}$ where std is a document image intensity standard deviation and γ is predefined parameter. We have to assign a value to the parameter γ that value is varied from dataset to dataset according to the quality of the output needed.γ is set high when we need more fine lines to be binarized and vice versa.

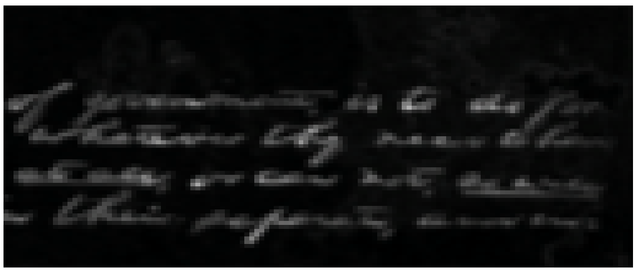

Fig 2: Contrast image constructed using proposed method of the sample document image in Fig 1(b)

B. Contrast Image Enhancement

The aim of the image enhancement is to improve the interpretability or perception of information in images for human viewers or to provide better input for other automated image processing techniques. Three functions are particularly suitable for contrast enhancement in MATLAB: imadjust, histeq, and adapthisteq.

- *imadjust* increases the contrast of the image by mapping the values of the input intensity image to new values such that, by default, 1% of the data is saturated at low and high intensities of the input data.
- *histeq* performs histogram equalization. It enhances the contrast of images by transforming the values in an intensity image so that the histogram of the output image approximately matches a specified histogram (uniform distribution by default).
- *adapthisteq* performs contrast-limited adaptive histogram equalization. Unlike histeq, it operates on small data regions (tiles) rather than the entire image. Each tile's contrast is enhanced so that the histogram of each output region approximately matches the specified histogram (uniform distribution by default). The contrast enhancement can be limited in order to avoid amplifying the noise which might be present in the image

C .Text Stroke Edge Pixel Detection

We can extract the foreground text from the document background once the high contrast edge pixels are detected properly. Text Stroke edge pixels can be detected easily by using, previously constructed enhanced contrast image. Adaptive image contrast computed at the text stroke is considerably higher than that computed within document background. Contrast map is then binarized using a global thresholding method which can extract the stroke edge pixels properly. Local image contrast and local image gradient are calculated within a local window and are evaluated by the difference between the maximum and minimum intensities in a local window.

Binarized contrast map is then combined with Canny's edge map .Canny's edge detector can detect the edges close to the real edge locations in the detecting image. The combined map consists of only those pixels that appear within both high contrast image pixel map and Canny's edge map .This helps to extract stroke edge pixels accurately.

D. Estimation of Local Threshold

After high contrast text stroke edge pixels are detected properly, we can segment the foreground text from the document background by a local threshold that is estimated based on the intensities of the detected text stroke edge pixels. If we analyze different kinds of document images we can observe that the text pixels are close to the detected text stroke edge pixels and there is a distinct intensity difference between the high contrast stroke edge pixels and the surrounding background pixels. The foreground text can be extracted based on the intensities of the detected text stroke edge pixels as follows:

$$R(x, y) = \begin{cases} 1 & I(x, y) \leq E_{mean} + \frac{E_{std}}{2} \\ 0 & \text{otherwise} \end{cases}$$

Where E_{mean} and E_{std} denote the mean and standard deviation of the intensity of the detected text stroke edge pixels within a local neighborhood window, respectively. The size of the local window should be larger than the stroke width. Therefore, we can set the local window size based on the stroke width *EW* of the document image. For that, we use an edge width estimation algorithm. By using this algorithm we calculate the most frequently occurring distance between two adjacent edge pixels.

Algorithm 1 Edge Width Estimation
Input: Degraded document image *I* and corresponding Binary Text Stroke Edge Image *Edg*
Output: Edge Width *EW*
1. Get the *width* and *height* of *I*
2. In the edge image, for each *Row i*=1 to height in *Edg* do
3. Scan from left to right, edge pixel candidates are selected as
   follows: a) Its label is 0 (background)
   b) The next pixel is labeled as 1(edge)
4. Examine the intensities of the selected pixels. Remove those pixels that have lower intensity than the following pixel next to it in the same row of *I*
5. Match the remaining adjacent pixels in the same row into pairs, then calculate the distance between pixels in the pair.
6. End for
7. Construct a histogram of calculated distances
8. Use this estimated most frequently occurring distance between adjacent pixels as stroke width

(a) (b)

Fig 3.Combined edge map corresponding to Fig 1(a) and 1(b) respectively

IV. RESULT AND ANALYSIS

The proposed paper discusses a document image binarization technique based on an improved adaptive image contrast. It involves only minimum number of parameters. It has been tested on various images in DIBCO datasets and Bickley diary datasets .The proposed document image binarization technique combines the local image contrast and local image gradient .The binarization performance of the proposed method is evaluated in terms of F-measure, PSNR, Negative Rate Matric (NRM) and Miss classification Penalty Metric (MPM).PSNR of proposed method is considerably higher than the previous methods. Value of F-measure, MPM and NRM are more close to the previous best performing methods. The proposed method also solve the over-binarization problem in the previous paper.

TABLE I

EVALUATION RESULTS OF THE DATASET OF DIBCO 2009

METHODS	F-MEASURE	PSNR	NRM($\times 10^{-2}$)	MPM($\times 10^{-2}$)
LMM	91.06	18.5	7	0.3
BASED ON ADAPTIVE IMAGE CONTRAST	93.5	19.65	3.74	0.43
PROPOSED METHOD	93.8	19.85	3.33	0.39

IV. CONCLUSION

This paper presents a document image binarization technique based on an improved adaptive image contrast .In this proposed technique, input degraded document image is first normalized to make contrast image enhancement easier. Then an adaptive image contrast map is constructed for the normalized input image.Second.Contrast image enhancement is performed. Third, Contrast map is binarized and combined with Canny's edge map to detect the text stroke edge pixels accurately.Finally,the document text is extracted by a local threshold that is estimated based on the intensities of the detected text stroke edge pixels.PSNR of proposed method is considerably higher than the previous methods. Value of F- measure, MPM and NRM are more close to the previous best performing methods.This type of document image binarization technique is suitable for different kind of degraded document images.

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AUTHOR'S PROFILE:

[1]. BIRADAR GEETA, Pursuing M.Tech in Department of Computer Science & Engineering at Malla Reddy College Of Engineering & Technology, Hyderabad,Telangana.India.

[2]. MADDURU SAMBASIVUDU, working as Asst.Professor in Department of Computer Science & Engineering, Malla Reddy College Of Engineering & Technology, Hyderabad, Telangana.India.