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Application of Binarization Technique in Enhancing Luminance and Text Stroke in a Deteriorated Image Document

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Abstract— **Binarization is been into intense research during the last few years. Image binarization is the method of separation of pixel values into dual collections, black as foreground and white as background. Document images often suffer from different types of degradation that renders the document image binarization a challenging task. Text Segmentation is a very difficult task from a degraded document images as the document image might contain lot of variations between the foreground and the background part. Most of the methods do not consider the nature of document images but rather developed algorithms depend on statistical methods. More specialized binarization techniques are the need of the hour. This paper uses adaptive image contrast technique. It combines local image contrast and the local image gradient and is tolerant towards variations caused due to degradations. It constructs an adaptive contrast for an input degraded document image. The contrast map is then binarized and combined with Canny's edge map to identify the text stroke edge pixels. A local threshold is calculated based on the intensities of detected text stroke edge pixels and this threshold is used for segmentation purpose.**

Index Terms— Degraded document, threshed, image binarization, adaptive image contrast, pixel classification.

I. INTRODUCTION

Image binarization is the process of separation of pixel values into dual collections, black as foreground and white as background. A binary image is a digital image that has just two feasible values meant for every pixel. Generally, two colors are used for a binary image i.e. black and white. But any two colors can be used. The color used for the objects in the image is the foreground color while the rest of the image is the background color. Binary images frequently occur in image processing as masks or as the outcome of some operations as segmentation and thresholding [1]. Few input/output devices, for example, laser printers, bi-level computer displays are able to just handle bi-level images. Binary images are formed from color images by segmentation. Binarization is one of the most important pre-processing steps which separates foreground and background of documents images. It converts a gray- scale document image into a binary document image.

Fig. 1a: Input image

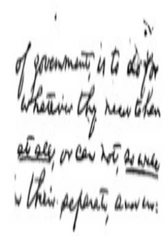

Fig: 1b: Binarized image

Fig: 1b: Binarized image

Document image binarization performance affects the degree of success in subsequent character segmentation and recognition. In general, image binarization is categorised in two main classes: (i) global and (ii) local. Most document analysis algorithms are built based on underlying binarized image data. Document image understanding methods require logical and semantic content preservation for thresholding. Though document image binarization has been studied for many years, the thresholding of images is still a challenging task due to the high variation between the text stroke and the document background. In this stage the grey-scale image converts into a binary image. A binary image can be processed well than a grey-scale image as illustrated in fig. 2;

Fig. 2 Binarization example

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This paper presents a document binarization technique that extends previous local maximum-minimum method [2]. The text that is handwritten within the degraded documents might contain a certain amount of variations like stroke width, stroke brightness, stroke connection, and document background. In addition, historical documents are often degraded where the ink of the other side seeps through to the front. Also they are often degraded by different types of issues like unhealthy storage. These different types of document degradations persuade the document thresholding error and make degraded document image binarization very complicated.

II. RELATED WORK

Many approaches like background subtraction texture analysis [3][4][5], recursive method, decomposition method, contour completion, Markov Random Field etc are also reported. These methods combine different types of image information and domain knowledge and are often complex. Thresholding techniques have been used for document image binarization. Majority of the adaptive local binarization methods disregard the edge property and lead to flawed results due to the fake shadows creation. For this, there exist approaches wherein they find seeds near the image edges and present an edge connection method to close the image edges to incorporate edge information. As many degraded documents do not have a clear bimodal pattern, global thresholding is usually not a suitable approach for the degraded document binarization. Adaptive thresholding [6], which estimates a local threshold for each document image pixel, is often a better approach to deal with different variations within degraded document images. The early window-based adaptive thresholding techniques [7] 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 technique is that the thresholding performance and character stroke width depends mostly on the window size. The local image contrast and the local image gradient are very useful features for segmenting the text from the document background. 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. The local contrast [6] is defined as follows.

Where $C(i, j)$ denotes the contrast of an image pixel $(i,$

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

$j)$, $I_{max}(i, j)$ and $I_{min}(i, j)$ 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 $I_{max}(i, j)$ and $I_{min}(i, j)$. Bernsen's method is simple, but cannot work properly on degraded document images with a complex document background. We have earlier proposed a novel document image binarization method [7] by using the local image contrast that is evaluated as follows:

$$C(i, j) = \frac{Imax(i,j) - Imin(i,j)}{Imax(i,j) + Imin(i,j) + \varepsilon} \qquad (2)$$

Where, ε is a positive but infinitely small number. 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. The small image contrast around the text stroke edges in Equation 1 (resulting from the shading) will be compensated by a small normalization factor (due to the dark document background) as defined in Equation 2.

III. DESIGN

The degraded document image is given as input & the improved document image is the desired output. The document image at each stage of contrast enhancement, threshold image and stroke enhanced image are shown as output. The following Figure illustrates the overall architecture of the technique.

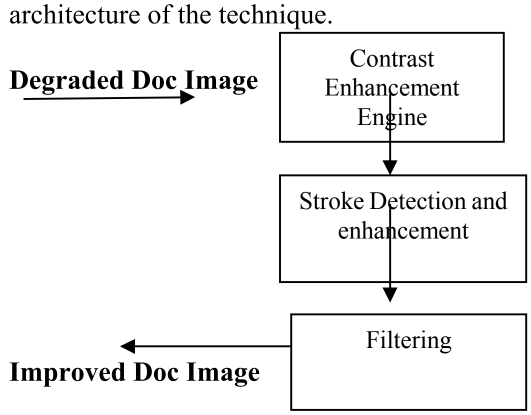

Fig. 3 Design

Contrast Enhancement Engine will enhance the contrast of the image in such a way the text stokes becomes bright. Stroke detection & enhancement will segment the image using edge detection method & improve the stoke width. Filtering will remove the background noises & improve the quality of the image.

IV. PROPOSED SYSTEM

This section describes the proposed document image binarization techniques. For the elimination of noisy areas, smoothing of background texture as well as contrast enhancement between background and text areas, a pre-processing stage of the grey scale source image is essential. Through the combination of the binarized adaptive contrast map and the canny edge map, for a given a degraded document image, first an adaptive contrast map is constructed and the text stroke edges are then detected. The document image contains multiple surface (texture) types that can be divided into uniform, and transiently changing. The texture contained in pictures and background can usually be uniform or differentiating categories, while the text, line drawings, are of transient properties by nature. The text is then segmented based on the local threshold that is estimated from the detected text stroke edge pixels. A post-processing is further applied at the end to improve the document binarization quality.

A. ***Contrast Image Construction***

The image gradient is used for edge detection and it can be used to detect the text stroke edges as well [8]. It detects many non-stroke edges from the background of degraded document that contains variations caused due to noise, uneven lighting, bleed-through, etc. Hence, in order to extract only the stroke edges, the image gradient needs to be normalized. In the earlier method [1], the local contrast evaluated by the local image maximum and minimum suppresses the background variation as described in Equation (2). In particular, the numerator (i.e. the difference between the local maximum and the local minimum) captures the local image difference similar to the traditional image gradient. The denominator is a normalization factor and suppresses the image variation within the document background. For image pixels within bright regions, a large normalization factor is produces 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 normalization factor accordingly. However, the limitation of image contrast in Equation (2) is that it may not handle document images with the bright text properly. To overcome this over-normalization problem, the local image contrast is combined with the local image gradient and an adaptive local image contrast is derived as follows:

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

Where $C(i, j)$ denotes the local contrast in Equation (2) and $(I_{max}(i, j) - I_{min}(i, j))$ refers to the local image gradient that is normalized to [0, 1].

B. ***Text Stroke Edge Pixel Detection***

The Canny's edge detector can be used to improve the binary map since it has a good localization property. The canny edge detector uses two adaptive thresholds and is more tolerant to different imaging artifacts such as shading [8]. The Canny's edge detector extracts a large amount of non-stroke edges as illustrated in Fig. 4 without tuning the parameter manually. The combination helps to extract the text stroke edge pixels accurately.

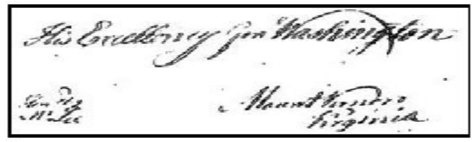

Fig. 4 Canny edge map

The purpose of the contrast image construction is to detect the stroke edge pixels. The constructed contrast image has a clear bi-modal pattern [1], where the adaptive image contrast computed at text stroke edges is larger than that computed within the document background. The local image contrast and the local image gradient are evaluated by the difference between the maximum and minimum intensity in a local window, the pixels at both sides of the text stroke will be selected as the high contrast pixels.

C. ***Local Threshold Estimation***

If the high contrast stroke edge pixels are detected properly, the text can then be extracted from the document background pixels. There are two characteristics from different kinds of document images [1]: First, the text pixels are close to the detected text stroke edge pixels. Second, there is a distinct intensity difference between the high contrast stroke edge pixels and the surrounding background pixels. Based on the detected text stroke edge pixels the document image text can thus be extracted as follows:

$$R(x, y) = \_\ 1 \quad I(x, y) \leq E_{mean} + E_{std} \quad (4)$$

E_{mean} and E_{std} are the mean and standard deviation of the intensity of the detected text stroke edge pixels within a neighbourhood window *W*, respectively.

The neighbourhood window should be at least larger than the stroke width. The size of the neighbourhood window *W* can be set based on the stroke width of the document image under study, *EW*, which can be estimated from the detected stroke edges as stated in Algorithm 1. We just calculate the most frequently distance between two adjacent edge pixels (which denote two sides edge of a stroke) in horizontal direction and use it as the estimated stroke width. First the edge image is scanned horizontally row by row and the edge pixel candidates are selected as described in step 3. If the edge pixels, which are labelled 0 (background) and the pixels next to them are labelled to 1 (edge) in the edge map (*Edg*), are correctly detected, they should have higher intensities than the following few pixels. So those improperly detected edge pixels are removed in step 4. In the remaining edge pixels in the same row, the two adjacent edge pixels are likely the two sides of a stroke, so these two adjacent edge pixels are matched to pairs and the distance between them are calculated in step 5. After that a histogram is constructed that records the frequency of the distance between two adjacent candidate pixels. The stroke edge width *EW* can then be approximately estimated by using the most frequently occurring distances of the adjacent edge pixels.

Algorithm 1 Edge Width Estimation

Require: The Input Document Image I and Corresponding Binary Text Stroke Edge Image Edg

Ensure: The Estimated Text Stroke Edge Width EW

1: Get the width and height of I

2: for Each Row i = 1 to height in Edg do

3: Scan from left to right to find edge pixels that meet the following criteria: a) its label is 0 (background); b) the next pixel is labelled as 1(edge).

4: Examine the intensities in I of those pixels selected in Step 3, and remove those pixels that have a 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, and calculate the distance between the two pixels in pair.

6: end for

7: Construct a histogram of those calculated distances.

8: Use the most frequently occurring distance as the estimated stroke edge width EW.

Algorithm 2 Post-Processing Procedure

Require: The Input Document Image *I*, Initial Binary Result *B* and Corresponding Binary Text Stroke Edge Image *Edg*

Ensure: The Final Binary Result B_f

1: Find out all the connect components of the stroke edge pixels in *Edg*.

2: Remove those pixels that do not connect with other pixels.

3: for Each remaining edge pixels (i, j): do

4: Get its neighbourhood pairs: $(i - 1, j)$ and $(i + 1, j)$; $(i, j - 1)$ and $(i, j + 1)$

5: if The pixels in the same pairs belong to the same class (both text or background) then

6: Assign the pixel with lower intensity to foreground class (text) and the other to background class.

7: end if

8: end for

9: Remove single-pixel artifacts [4] along the text stroke boundaries after the document thresholding.

10: Store the new binary result to B_f.

CONCLUSION

The binarization technique used here is found to be tolerant towards different document degradation like uneven illuminations, variations and smear. The usage of less parameter has proved that the technique is simple and robust. This paper presents an adaptive algorithm for document image binarization that makes use of adaptive approach to manage different situations in an image. The local image contrast used here is evaluated based on the local maximum and minimum. The technique also works for different kinds of degraded document images.

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