International Journal of Research Studies in Science, Engineering and Technology
Volume 1, Issue 8, November 2014, PP 64-70
ISSN 2349-4751 (Print) & ISSN 2349-476X (Online)

Simple and Efficient Method of Contrast Enhancement of Degraded Document Image through Binarization

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Abstract: *Text Segmentation from a degraded document images is a very difficult task as the document image might contain lot of variations between the foreground and the background part. Binarization is been into intense research during the last few years. Most of the developed algorithms depend on statistical methods and do not consider the nature of document images. However, recent developments call for more specialized binarization techniques. Adaptive image contrast is used as a binarization technique in this paper. The adaptive image contrast is a combination of the local image contrast and the local image gradient. It is also tolerant towards variations caused due to is estimated based on the intensities of detected text stroke edge pixels within a local window and this threshold is used for segmentation purpose.. The proposed method is simple, robust, and involves minimum parameters.*

Keywords: *Adaptive image contrast, document analysis, document image processing, degraded document image binarization, pixel classification.*

1. INTRODUCTION

Document image binarization plays a key role in document processing since its 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. binarization is a preprocessing stage for document analysis and it is used to segment the foreground text from the document background. This technique ensures faster and accurate document image processing tasks. Most document analysis algorithms are built based on underlying binarized image data. The use of bilevel decreases the computational load and helps in using simplified analysis methods compared to 256 levels of grey-scale or colour image information. 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 binarization. In this stage the grey-scale image converts into a binary image. a binary image can be processed better than a grayscale image as illustrated in fig. 1, the handwritten text 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 by the bleed through, where the ink of the other side seeps through to the front. Also they are often degraded by different types of imaging artifacts. These different types of document degradations induce the document thresholding error and make degraded document image binarization very difficult. This paper presents a document binarization technique that extends previous local maximum-minimum method

Fig.1. *Binarization example*

The proposed method also involves minimum parameter tuning. It makes use of the adaptive image contrast that combines the local image contrast and the local image gradient adaptively. Hence the method handles different types of document degradations. It also addresses the over-normalization problem of the local maximum minimum algorithm. The parameters used in the algorithm can be easily and adaptively estimated and hence the method can be simple and robust.The rest of this paper is organized as follows. Section II first reviews the current state-of-the-art binarization techniques. Section III deals with the design and IV contains a simulation results of binarization technique and finally, conclusions are presented in Section V.

2. Related Work

Most of the adaptive local binarisation methods ignore the edge property and lead to erroneous results due to the creation of fake shadows. For this, there exist approaches that also incorporate edge information as in wherein they find seeds near the image edges and present an edge connection method to close the image edges. Many thresholding techniques have been used for document image binarization. As many degraded documents do not have a clear bimodal pattern [10], global thresholding [2] is usually not a suitable approach for the degraded document binarization. Adaptive thresholding [3], 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 [5] estimate the local threshold by using the mean and the standard variation of image pixels within a local neighborhood window. The main drawback of this technique is that the thresholding performance and character stroke width depends mostly on the window size. Other approaches have also been reported, including background subtraction texture analysis, recursive method [4], decomposition method, contour completion, Markov Random Field etc. These methods combine different types of image information and domain knowledge and are often complex. 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 neighboring document background. They are very effective and have been used in many document image binarization techniques. In Bernsen's rule , the local contrast is defined as follows.

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

Where $C(i, j)$ denotes the contrast of an image pixel (i, j), $I_{max}(i, j)$ and $I_{min}(i, j)$ denote the maximum and minimum intensities within a local neighborhood windows of (i, j), respectively. If the local contrast $C(i, j)$ is smaller than 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 by using the local image contrast that is evaluated as follows:

$$C(i, j) = \frac{I_{\max}(i, j) - I_{\min}(i, j)}{I_{\max}(i, j) + I_{\min}(i, j) + \epsilon} \quad (2)$$

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. Take the text within shaded document areas such as that in the sample document image in Fig. 1 as an example. 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.

3. 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 illustatres the overall architecture of the technique.

Contrast Enhancement Engine: will enhance the contrast of the image in such a way the text stokes becomes bright.

Stroke detection & enhancement: This module will segment the image using edge detection method & improve the stoke width.

Filtering: This module will remove the background noises & improve the quality of the image.

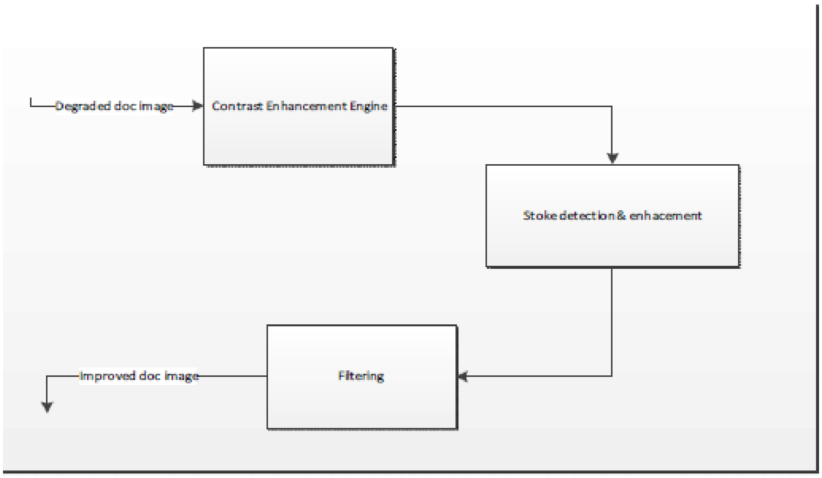


Fig.3. *Design*

3.1 Local Image Gradient

An image gradient is a directional change in the intensity or color in an image. Image gradients may be used to extract information from images. In graphics software for digital image editing, the term gradient or color gradient is used for a gradual blend of color which can be considered as an even gradation from low to high values, as used from white to black in the images to the right. Another name for this is color progression.

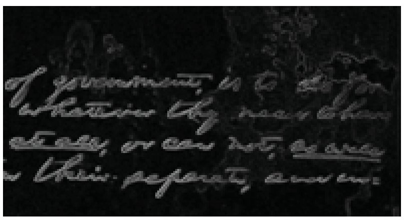
Mathematically, the gradient of a two-variable function (here the image intensity function) at each image point is a 2D vector with the components given by the derivatives in the horizontal and vertical directions. At each image point, the gradient vector points in the direction of largest possible intensity increase, and the length of the gradient vector corresponds to the rate of change in that direction.

Since the intensity function of a digital image is only known at discrete points, derivatives of this function cannot be defined unless we assume that there is an underlying continuous intensity function which has been sampled at the image points. With some additional assumptions, the derivative of the continuous intensity function can be computed as a function on the sampled intensity function, i.e., the digital image. It turns out that the derivatives at any particular point are functions of the intensity values at virtually all image points. However, approximations of these derivative functions can be defined at lesser or larger degrees of accuracy.

The Sobel operator represents a rather inaccurate approximation of the image gradient, but is still of sufficient quality to be of practical use in many applications. More precisely, it uses intensity values only in a 3×3 region around each image point to approximate the corresponding image gradient, and it uses only integer values for the coefficients which weight the image intensities to produce the gradient approximation.

The image gradient has been widely used for edge detection and it can be used to detect the text stroke edges of the document images effectively that have a uniform document background. On the other hand, it often detects many nonstroke edges from the background of degraded document that often contains certain image variations due to noise, uneven lighting, bleed-through, etc. To extract only the stroke edges properly, the image gradient needs to be normalized to compensate the image variation within the document background. (Imax(i, j) − Imin(i, j)) is refers to the local image gradient that is normalized to [0, 1].

Sample output of image gradient is



3.2 Adaptive Image Contrast

To overcome this over-normalization problem, we combine the local image contrast with the local image gradient and derive an adaptive local image contrast as follows:

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

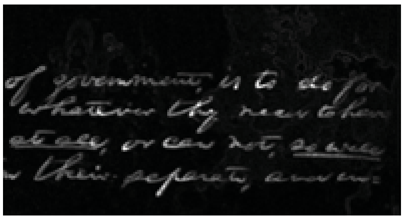
where C(i, j) denotes the local contrast in Equation 2 and (Imax(i, j) − Imin(i, j)) refers to the local image gradient that is normalized to [0, 1]. The local windows size is set to 3 empirically. α is the weight between local contrast and local gradient that is controlled based on the document image statistical information. 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 and avoid the over normalization problem.

We model the mapping from document image intensity variation to α by a power function as follows:

$$\alpha = \left(\frac{Std}{128}\right)^{\gamma}.$$

Where Std denotes the document image intensity standard deviation, and γ is a pre-defined parameter. The power function has a nice property in that it monotonically and smoothly increases from 0 to 1 and its shape can be easily controlled by different γ .γ can be selected from [0,∞], where the power function becomes a linear function when γ = 1.

Sample output of adaptive image contrast is



3.3 Binarization

A binary image is a digital image that has only two possible values for each pixel. Typically the two colors used for a binary image are black and white though any two colors can be used. The color used for the object(s) in the image is the foreground color while the rest of the image is the background color. In the document scanning industry this is often referred to as bi-tonal.

Binary images are also called bi-level or two-level. This means that each pixel is stored as a single bit (0 or 1). The names black-and-white, B&W, monochrome or monochromatic are often used for this concept, but may also designate any images that have only one sample per pixel, such as gray scale

4. Simulation Results

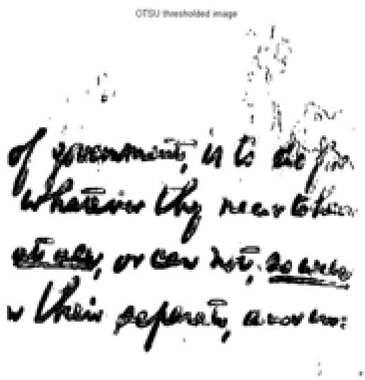
Input Image:

1) Contrast Image:

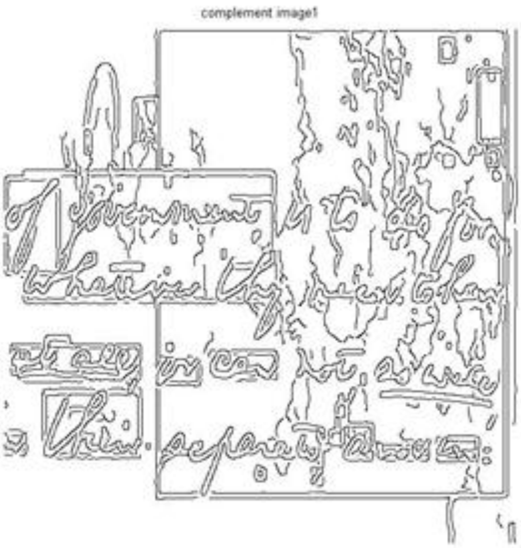
2) Gradient Image:

6. Adaptive Contrast Image:

6. Otsu Tresholding Image:



7. Canny Edge Image



8. Combined Image:

5. CONCLUSION

This paper presents an adaptive algorithm for document image binarization that makes ues of adaptive approach to manage different situations in an image. 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. The technique also works for different kinds of degraded document images. The local image contrast used here is evaluated based on the local maximum and minimum. The method is experimented on various datasets as discussed earlier and has outperformed the other methods.

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