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Survey on Image Binarization Techniques for Degraded Document Images

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***Abstract*—** I There are many methods for enhancement of degraded document images. In the process of improving degraded document images segmentation is one of the difficult task due to background and foreground variation such as uneven illumination, document smear such as smudging of text, seeping of ink to the other side of paper, degradation of paper ink due to aging etc. A number of methodologies have been proposed by several researchers on image segmentation using binarization technique. In document analysis, binarization is easily affected by noise, surrounding illumination, gray-level distribution, local shading effects, weak contrast, and the presence of dense non-text components such as photographs. So binarization can become a challenging job under varying illumination and noise. This survey aims to evaluate the principles of image binarization techniques. The main objective of this paper is to evaluate the different image binarization techniques to find the gaps in existing techniques.

Keywords— Degraded document image binarization, Global thresholding, Local thresholding, Dynamic thresholding, Adaptive binarization, Hybrid binarization

I. INTRODUCTION

Image binarization [10] is the process of grouping the pixel values into two collections, black as foreground and white as background. After years of studies in document image binarization, the thresholding of degraded document images is still found to be a very difficult task because of the high inter/intra variation between the text stroke and the document background across various document images. The stroke width, stroke connection, stroke brightness and document background vary in the handwritten text within the degraded documents. Moreover, bleed through degradation is observed in historical documents. For most of the existing techniques many kinds of document degradations are still an unsolved problem of degraded document image binarization due to the document thresholding error. Thresholding is considered to be a well-known technique used for binarization of document images. Thresholding is further divided into global and local thresholding techniques. For document images of a good quality with uniform contrast delivery of background and foreground, global thresholding is the best technique and it is efficiently capable to extract the document text. In degraded documents, where extensive background noise or difference in contrast and brightness exists i.e. it contain many pixels that cannot be effortlessly categorized as foreground or background. In such cases, local thresholding is the best technique over available techniques, which estimates a local threshold for each document image pixel and it is usually capable of producing much better binarization results. The main objective of this paper is to evaluate the different image binarization techniques to find the gaps in existing techniques.

A binary image is a digital image that has just two feasible values meant for every pixel. Usually two colors, black and white are used for a binary image. However 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 are formed from color images by segmentation. There are so many approaches as well as techniques were developed to improve documents images quality. Binarization is one of the most important pre-processing steps which will separate foreground and background of documents images. It converts a gray-scale document image into a binary document image.

II. GENERAL DOCUMENT BINARIZATION TECHNIQUES

A large number of document image binarization techniques have been reported in the literature [10]. Generally, they can be classified into four major types: global binarization, local binarization, hybrid binarization and dynamic thresholding methods.

A. The Global Thresholding Technique

This method [10] computes an optimal threshold for the entire image; these techniques need few computations and can work well in simple cases. But fails in complex backgrounds such as non-uniform color and poor illuminated backgrounds. These methods are usually not suitable for degraded document images, because they do not have a clear pattern that separates foreground text and background.

B. The Local Binarization Techniques

This method [10] uses different thresholds for different target pixels depending on their neighborhood/local information. Generally, these techniques are sensitive to

background noises due to large variance in case of a poor illuminated document or bleed through degradation.

C. *Hybrid Binarization Techniques*

This method [10] combines global and local thresholding. In the first step performs a global thresholding for classifying a part of the background of the document image and keep only the part containing the foreground (graphics or text in our case). A second step aims to refine the image obtained by the previous step in order to obtain a sharper result by applying an adaptive thresholding technique.

D. *Dynamic Threshold Binarization*

In this method [10] an iteration method is used. It defines the threshold of a pixel based on the grey-level values of its own and neighboring pixels and the pixel's coordinate. This binarization method is commonly used for the bad quality images, especially the images with single peak histogram. However, according to the dynamic threshold calculation, the method has high computation complexity and slow speed.

III. CLASSICAL METHODOLOGIES

A number of methodologies have been proposed by several researchers on image segmentation using binarization and its applications. Several researchers have proposed a variety of thresholding techniques for binarization of document images. The binarization methods can be categorized into different groups based on the principal criteria they are used for calculating the threshold. The table 1 below shows a comparison of some of the classical methodologies [1,2,3,4,11] found in the literature.

Method	Description	Advantage	Limitation
Otsu's method	Automatically performs histogram shape-based image thresholding.	Calculates the optimum threshold so intra-class variance is minimal.	Gives satisfactory results when the numbers of pixels in each class are close to each other.
Niblack's method	Calculates pixel-wise threshold.	Deal with different variations within degraded document images.	The Quality of binarization depends on the size of the sliding window
A multi-scale framework for adaptive binarization of degraded document images	Combine the framework with recursive adaptive methods for restoring document images suffering from bleed through degradation.	Enhance the binarization results and used along with any adaptive threshold -based binarization method.	Requires several binarization methods on different scales, which is focused by introduction of fast grid-based models.
Dynamic thresholding of gray-level images	Uses local adaptive method which is based on contrast of an image.	It is a simple method. The local image contrast used here is a very useful feature for segmenting the text from the document background.	Depends on threshold value and window size. It cannot work properly on document images with complex document background.

Table 1**:** Comparison of different classical methodologies

IV. RECENT WORKS

In this section, different image binarization methods are discussed.

A. *Pixel-based binarization evaluation methodology*

A pixel-based binarization evaluation methodology for historical handwritten/ machine-printed document images is presented in [5]. In the evaluation scheme in the proposed method, the recall and precision evaluation measures are properly modified using a weighting scheme that diminishes any potential evaluation preference. Additional performance metrics of the proposed evaluation scheme consist of the percentage rates of missed and broken text, false alarms, background noise, character enlargement, and merging. The validity of the method is proved by several experiments conducted in comparison with other pixel-based evaluation measures.

B. *A combined approach for the binarization of handwritten document images*

There are so many challenges addressed in handwritten document image binarization, such as faded characters, bleed-through, and large background ink stains. Most, binarization methods cannot deal with all the degradation types effectively. Motivated by the low detection rate of faded characters in binarization of handwritten document images, a combination of a local and global adaptive binarization method at connected component level is proposed in [6].It will provide an improved overall performance. Firstly, background estimation is applied along with image normalization based on background compensation. After that, global binarization is performed

on the normalized image. After binarization very small components in the binarized image are discarded and representative characteristics of a document image such as the stroke width and the contrast are computed. In addition, local adaptive binarization is performed on the normalized image taking into account the above characteristics. In the final stage, the two binarization outputs are combined at connected component level. Authors report good performance after extensive testing on the DIBCO series datasets which include a variety of degraded handwritten document images.

C. *Binarization of degraded document image based on feature Space partitioning and classification*

Paper [7] proposes another algorithm for the binarization of degraded document images. The image is mapped into a 2D feature space in which the text and background pixels are separable, and then this feature space is divided into small regions without using any training dataset. These regions are labeled as text or background using the result of a basic binarization algorithm applied on the original image. Finally, each pixel of the image is grouped as either text or background based on the label of its corresponding region in the feature space. In addition, this algorithm does not need any parameter setting by the user and is suitable for various types of degraded document images. The proposed algorithm proves that its superior performance against six well-known algorithms on three datasets.

D. *An adaptive local binarization method for document images based on a novel thresholding method and dynamic windows*

The majority of binarization techniques are complex and are compounded from filters and existing operations. However, some of the few available simple thresholding methods cannot be applied to many binarization problems. In [8], a local binarization method is presented. It is a simple, novel thresholding method with dynamic and flexible windows. This method is tested on selected samples of DIBCO 2009 benchmark dataset.

E. *Binarization of Historical Document Images Using the Local Maximum and Minimum*

A novel document image binarization method by using the local image contrast that segments the text from badly degraded historical document images proposed in[9]. The proposed technique makes use of the image contrast that is defined by the local image maximum and minimum. The image contrast evaluated by the local maximum and minimum has a nice property compared with the image gradient and it is more tolerant to the uneven illumination and other types of document degradations. For a historical document image, the proposed method first constructs a contrast image and then detects the high contrast image pixels which usually lie around the text stroke boundary. The document text is then separated by using local thresholds that are estimated from the detected high contrast pixels within a local neighborhood window. The proposed method has been tested over the dataset that is used in the recent Document Image Binarization Contest (DIBCO) 2009 and these experiments show its superior performance.

CONCLUSION

This paper has focused on the degraded document binarization techniques. The main objective of this paper is to evaluating the short comings of existing methods for degraded image binarization. The main limitation of existing work is noisy and low intensity images. A guided filter (best edge preserving filter) is needed to reduce the noise from the image that will increase the accuracy of the available binarization methods. Also, for most of the techniques; an adaptive contrast enhancement is required to improve the accuracy. Finally there is a need of an edge map which has the ability to map the exact character in an efficient manner. It has been concluded from the existing research is that each technique has its own benefits and limitations; no technique is perfect for every case. As per study and experiments, there is a need of a new novel method which will use more reliable methodology to enhance the binarization to achieve more accuracy and speed to improve the results further.

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