

# A Review of Document Image Binarization Techniques

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**Abstract**—Binarization is very important pre-processing technique for document images which is used to segment the image into foreground and background pixels. Binarization of degraded documents is very challenging due to uneven background, noise, ink dots, degradation of paper ink due to aging etc. Although many binarization techniques are available, but these standard algorithms are sensitive to noise and do not produce good results on different kinds of degradations. The selection of binarization method for a particular degradation is a very tedious job. In this paper, a survey of recent ongoing research efforts in field of image binarization has been carried out. The purpose of this study is to find the research gap in the field of document image binarization.

**Keywords**—Binarization, Degraded documents, Thresholding, OCR, Document images.

## I. INTRODUCTION

Image binraization is an important pre-processing step of document image analysis. Image Binarization transforms a gray image with 256 levels to bi-level binary image [3]. Binarization is used to segment image into two parts: foreground and background. Binarization helps in increasing speed of document image processing tasks such as text segmentation and optical character recognition (OCR). Every pixel of document image is either classified as background or foreground by comparing its intensity with a threshold value. But selecting the optimum threshold value is a very challenging task. Incorrect selection of threshold value may result in misclassification of pixels from foreground to background and vice-versa [10]. Good quality of binraization helps in improving the results of character recognition system [13]. Figure 1(a) shows a greyscale image and (b)-(e) show corresponding binarized images at multiple threshold values.

Binraization methods are very sensitive to noise, ambient light, shadows and poor contrast [10]. Binraization has been commonly used in various fields such as face, Iris and text recognition, scene text recognition, medical image processing and pattern recognition etc. [4].

Rest of the paper is organized as follows, Section I contains the introduction of document image binarization, Section II describe the thresholding method of binarization, Section III



Figure 1. (a) Original image and (b)-(e) are multilevel thresh binarized images

contains the related work of image binarization, Section IV concludes research work with future directions.

## II. THRESHOLDING BASED BINARIZATION

Thresholding is one of the simplest image segmentation method for classification of image into foreground and background. Thresholding techniques are generally classified into global and local (adaptive) methods. Global method use a single threshold value to segment the whole image, while local method uses a varying threshold value for different parts of the image. The results of various thresholding methods for image binarization are shown in fig. 2. The main difference between various approaches is to select the suitable threshold value for segmenting the document.

**A. Global thresholding**

The global threshold has been a popular and fast method to convert a grayscale image into binary image. Global thresholding uses a single threshold value for the whole image. The pixels whose intensity is smaller than threshold value are classified as background pixels and pixels with higher intensity as foreground pixels. Generally background is represented by black pixels and foreground with white pixels (or vice-versa). Global threshold provides good results for high quality and noise free images. Global thresholding fails for the documents images with complex background. Global thresholding is also not able to handle changes in illumination, scanning errors and poor quality document images.

•Otsu thresholding: Otsu is a well-known and most standard global thresholding method to calculate threshold value automatically [15]. This technique produces good results and have fast execution time. In this method, threshold value is selected on the basis of intensity histogram of the image. Otsu calculate that threshold value which minimizes the weighted within class variance between two different classes of foreground and background. Figure 2 (b) shows the result of thresholding by Otsu method.

**B. Local (Adaptive) thresholding**

Threshold value is calculated either at pixel level or selecting an image neighborhood. A single threshold generally does not provide good results in document images, because of uneven illumination or shadows.

- a. Niblack thresholding: A rectangular window is used as a mask and slided over a grey scale image to compute the thresholding of pixels in that portion of the image [12]. Niblack is not efficient for images having background noise.
- b. Bernsen thresholding: It is the local Binraization technique used for calculating the threshold value for each pixel in entire image [5].
- c. Sauvola thresholding: It is the modified form of Niblack’s algorithm [6]. Sauvola provides better results than Niblack based on various conditions such as light variation on document image, light texture etc. The Sauvola method is provides improved results than Niblack’s technique when the gray-level images convert into the black and white images.

**III. RECENT WORKS**

Jia et.al. proposed an approach for local thresholding of degraded document images using structure symmetry of neighboring pixels. Firstly global binarization has been carried out on compensated gradient map of the degraded image and then stroke width of neighborhood is estimated. Finally, voting based multiple threshold framework has been used to improve the accuracy. The results of the proposed methodology with several state-of-the-art techniques on seven public database demonstrate the accuracy and robustness of the method [1].

Jia et.al. presented an original local thresholding method using structure symmetric pixels (SSP) for degraded document images. After calculating the gradient map of the image and estimating background surface, SSP candidate pixels are extracted and then detect all the stroke edges of degraded document images. The results of the study are comparable to the well-established standard algorithms on two public datasets [2].

Bolan et.al. presented a document binraization method for degraded images using combination of local image contrast and local gradient map. The generated contrast map of degraded image is binarized and joined with canny edge map. Further local segmentation has been carried out based on intensity of text stroke pixels. The results of proposed technique on various public datasets mostly outperform the best known methods [3].

Mysore et.al. presented a solution using mean-shift based segmentation on colour document images at several scales and a variant of Niblack thresholding method. The results

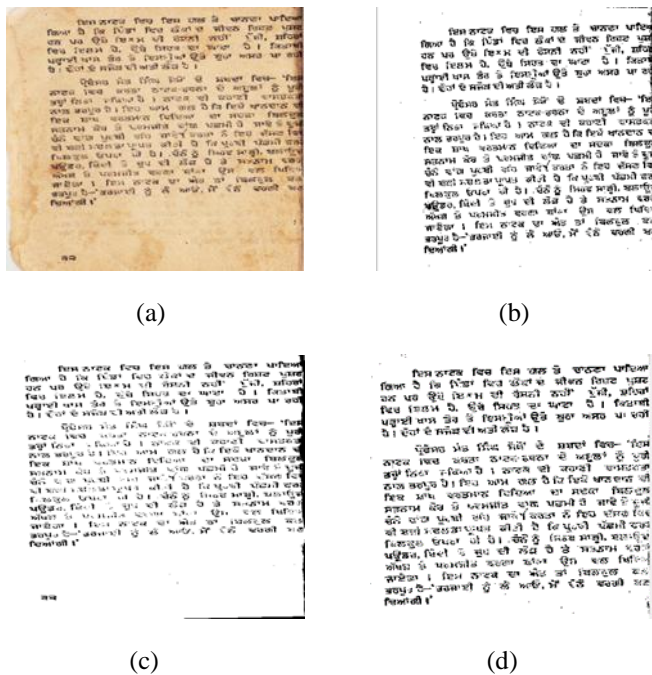


Figure 2. Results of various image thresholding methods on (a) Original Grayscale image, Image after (b) Global thresholding (c) Local thresholding (d) Adaptive thresholding

produced by technique are quite encouraging and comparable to best available methods [4].

Saulva & Pietikäinen proposed a local adaptive document binarization technique which first classify the document parts into text, background and figure. Then threshold for textual and non-textual components has been calculated separately binarized using histogram based and soft decision methods respectively. Finally text binarization has been carried out with a reformed Niblack method by combining above threshold values. The results obtained by study on large public dataset demonstrate the effectiveness of the proposed approach on various type of degraded images [6].

Boundraa et.al. proposed a binarization method for degraded documents using fusion of three popular methods namely Otsu, Nick and multi-level Otsu binarization. Along with it, preprocessing method CLAHE and post-processing techniques has been used to remove the noise and improve the quality of image to produce better results. The results of method on public datasets show that method is able to accurately binarize documents with noise and low contrast [7].

Nitrogainnis et.al. presented a binarization method especially to improve the recognition of faint handwritten character by combining global and local adaptive method at connected component level. The method performs very well on standard dataset of handwritten degraded images [8].

Valverde & Grigat presented an automatic locally adaptive based method using Niblack's binarization and steps for validation. The two validations are based on morphology and gradient Author is able to achieve excellent results by restoring alphanumeric labels and low contrast area [9].

Trier & Taxt experimentally reviewed the performance of 11 locally adaptive binarization methods of greyscale images containing various degradation and noise. Niblack's method with additional post-processing steps of yonowitz and bruckstein's method has been found to be performing very well in terms of both accuracy and speed [13].

Graham et.al. introduces two new thresholding based methods for difficult images containing noise, low contrast and varying illumination. A total of five methods has been selected for comparison and precision and recall has been used to compare the quality of thresholding. The authors concluded that best binarization algorithm depends on type of image [14].

Otsu introduces a very simple automatic optimal threshold selection method based on the discriminant criteria on image histogram. The method can also be extended to multi-threshold problems. The findings of the method are supported with results on various example images [15].

Gatos et.al. proposed a new adaptive approach for binarization of degraded documents which does not require any parameters from user. The method follows multiple steps, starting with pre-processing using low-pass wiener filter. Then background surface has been estimated using sauvlova's approach. Final thresholding has been applied to the image by combining background surface and original image [16].

Jindal et.al. presented a summary of various type of degradations such as touching and broken characters present in printed Gurumukhi script. Touching characters problem is due to low quality newspapers, aging of old books in which two neighboring characters overlap with each other. Broken characters are usually present in fax document and light printed magazines in which a character is broken into more than one components [17].

Trier & Jain presented a performance evaluation of eleven local adaptive binarization methods for low-level images using goal directed approach. Results were presented based on accuracy of digit recognition module by comparison with eleven local adaptive methods. Niblack method has been found to be outperforming as compared to other techniques [18].

Sahoo et.al. presented an extensive survey and performance evaluation of various global thresholding techniques. The evaluation has been carried out on standard dataset images using parameter such as uniformity and shape measures [19].

Table 1. Comparison of various binarization techniques

Author	Year	Technique
Jai et.al. [1]	2018	Used SSP to calculate the local threshold in neighborhood and using Multivote based system to test that pixel belong to background or foreground
Jai et.al. [2]	2016	Extract the potential SSP using estimation of background surface and computing the gradient map. calculate the local thresholding of each pixel using SSP
Su et.al. [3]	2013	Adaptive contrast map is constructed using combination of binarized adaptive contrast map and canny edge detection
Mysore.et.al [4]	2016	Mean shift filtering and contrast enhanced by Niblack
Saulva and Pietikäinen [6]	2000	local thresholding of each pixel using SDM and TDM
Valverde & Grigat[9]	2000	Niblack's Binarization, and validation using morphological image processing and gradient based decisions

#### IV. CONCLUSION AND FUTURE SCOPE

In this paper, a survey of various types of document image binarization techniques has been carried out. The main goal of this study is to review the various existing algorithms for

degraded document image binarization. Many techniques have been proposed in past to binarize the document images. A single method is not able to carry out successful binarization for all kind of degradations. No technique is best performing for every case of degradation. Suitable binarization method has to be selected for different degradation.

Few studies have been reported in literature for binarization of degraded documents of Indian scripts in general and Gurmukhi in particular. In future, suitable image binarization method for these scripts will be investigated.

### REFERENCES

- [1] F. Jia, C. Shi, K. He, C. Wang, B. Xiao, "Degraded document image binarization using structural symmetry of strokes", *Pattern Recognition*, Vol. **74**, pp. **225-240**, **2018**.
- [2] F. Jia, C. Shi, K. He, C. Wang, B. Xiao, "Document image binarization using structural symmetry of strokes", In the proceedings of 15th International Conference on Frontiers in Handwriting Recognition (ICFHR), Shenzhen, **China**, pp. **411-416**, **2016**.
- [3] S. Bolan, S. Lu, C.L. Tan, "Robust document image Binarization technique for degraded document images" *IEEE Transactions on Image Processing*, Vol. **22**, Issue **4**, pp. **1408-1417**, **2013**.
- [4] S. Mysore, M.K. Gupta, S. Behle, "Complex and degraded color document image binarization", In the proceedings of 2016 3rd International Conference on Signal Processing and Integrated Networks (SPIN), Noida, **India**, pp. **157-162**, **2016**.
- [5] J. Bernsen, "Dynamic Thresholding of Gray Level Image", In the proceedings of International Conference on Pattern Recognition ICPR '86, **Berlin**, pp. **1251-1255**, **1986**.
- [6] J. Saulva, M. Pietikäinen, "Adaptive document image binarization", *Pattern Recognition*, Vol. **33**, Issue **2**, pp. **225-236**, **2000**.
- [7] O. Boudraa, W.K. Hidouci, D. Michelucci "A robust multi stage technique for image binarization of degraded historical documents" In the proceedings of 5th International Conference on Electrical Engineering (ICEE-B), **Boumerdes**, pp. **1-6**, **2017**.
- [8] K. Ntirogiannis, B. Gatos, I. Pratikakis "A combined approach for the binarization of handwritten document images" *Pattern Recognition Letters*, Vol. **35**, pp. **3-15**, **2014**.
- [9] J.S. Valverde, R.R. Grigat. "Optimum binarization of technical document images", In the proceedings of International Conference on Image Processing. Vancouver, **Canada**, pp. **985-988**, **2000**.
- [10] N. Chaki, S.H. Shaikh, K. Saeed, "A Comprehensive Survey on Image Binarization Techniques" In *Exploring Image Binarization Techniques*. Vol. **560**. **Springer, India**, pp. **5-15**, **2014**.
- [11] B. Su, S. Lu, C.L. Tan. "Combination of document image binarization techniques", In the proceedings of International Conference on Document Analysis and Recognition (ICDAR), Beijing, **China**, pp. **22-26**, **2011**.
- [12] R. Firdousi, S. Parveen. "Local Thresholding Techniques in Image Binarization" *International Journal of Engineering and Computer Science*, Vol. **3**, No. **3**, pp. **4062-4065**, **2014**.
- [13] Ø.D. Trier, T. Taxt, "Evaluation of binarization methods for document images", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. **17**, Issue **3**, pp. **312-315**, **1995**.
- [14] G. Leedham, C. Yan, K. Takru, J.H.N. Tan, L. Mian, "Comparison of some thresholding algorithms for text/background segmentation in difficult document images", In the proceedings of Seventh International Conference on Document Analysis and Recognition (ICDAR), Edinburgh, **UK**, pp. **859-864**, **2003**.
- [15] N. Otsu, "A threshold selection method from gray-level histograms", *IEEE transactions on systems, man, and cybernetics*, Vol. **9**, Issue **1**, pp. **62-66**, **1979**.
- [16] B. Gatos, I. Pratikakis, S.J. Perantonis, "Adaptive degraded document image binarization", *Pattern Recognition*, Vol. **9**, Issue **3**, pp. **317-327**, **2006**.
- [17] M.K. Jindal, R.K. Sharma, G.S. Lehal, "A study of different kinds of degradation in printed Gurmukhi script". In the proceedings of International Conference on Computing: Theory and Applications, (ICCTA'07), Kolkata, **India**, pp. **538-544**, **2007**.
- [18] Ø.D. Trier, A.K. Jain, "Goal-directed evaluation of binarization methods", *IEEE Transactions on Pattern Analysis & Machine Intelligence*, Vol. **17**, Issue **12**, pp. **1191-1201**, **1995**.
- [19] P.K. Sahoo, S. Soltani, A.K.C. Wong, Y.C. Chen, "A survey of thresholding techniques", *Computer vision, graphics, and image processing*, Vol. **41**, Issue **2**, pp. **233-260**, **1988**.

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