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A Hybrid Image Binarization Technique for Enhancement of Degraded Document Images

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***Abstract*— Image processing is a process of analysis and manipulation of digital images, which improves the quality of an image. Image binarization is a pre-processing step which improves the quality of the image. Image binarization is used to improve the image quality and it segment the pixel values into two categories; i.e. black pixel as foreground and white pixel as background. In this research work, binarization techniques are applied to improve the quality of the degraded document images. Different types of image binarization methods used in this work are Otsu, Nick, Niblack and Sauvola. In addition to this, a new hybrid binarization method is proposed which is a combination of local and global method. Performance factors used are PSNR (Peak Signal to Noise Ratio) and NRM (Negative Rate Metric). From the results, it is observed that the proposed hybrid binarization has produced good results than existing methods.**

***Index Terms*— Document images, Binarization, Otsu, Nick, Niblack, Sauvola, Hybrid**

1. INTRODUCTION

Image processing is a process of analysis and manipulation of digital images, to improve the quality of an image. Document Image analysis is to distinguish the text and graphics components of an image documents to extract intended information from them [1]. Image binarization is an initial pre-processing step in document image processing and image analysis. Image binarization process segments the pixel using image binarization technique in order to get the clear values into two categories, i.e. black as foreground and white as background. The degraded document images are enhanced images from the original degraded images. There are many difficulties addressed in the historical documents which are frequently degraded. Hand written documents are very challenging to handle than the machine-printed documents because they lack a specific structure [2][5]. For example, in handwritten documents the character may overlap, linked within a words and different font size from different text lines may be connected due to the different writing style. In addition, the use of pen quills, which was generally, used in historical handwritten documents, which is highly responsible for some degradation such as faint, shadowy characters, ink bleeds and large stains.

Many document image binarization approaches have been proposed which are generally divided into different categories namely, Global thresholding, Local thresholding and Partition based thresholding. The global thresholding technique computes an optimal threshold for the entire image; these techniques need few computations and can work well in simple cases but usually not suitable for degraded document images, it does not have a clear pattern that separates foreground and background image. In Local thresholding method, a threshold is computed at each pixel, which is calculated on some local values such as range, variance or surface fitting parameters of the neighborhood pixel[3][6].

This method is statistically examining the intensity values of the neighborhood of each pixel. Hybrid thresholding approach combines global and local thresholding methods. First step carrying out a global thresholding, i.e. it classifies the part of the background of the document image and keep only foreground of that part (graphics or text in our case). 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.

The remaining portion of the paper is organized as follows. Section 2 discusses the related works. Existing and the proposed binarization techniques are presented in Section 3. Section 4 provides experimental results and conclusion is given in Section 5.

2. RELATED WORKS

B. Gatos.et.al.,[3] described a novel locally adaptive approach for the binarization and enhancement of degraded documents. The author proposed a method that does not requires any parameters for the user and it can deal with degradations which may occur due to shadows, non-uniform illuminations, low contrast smear and strain

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Vol 4, Issue 10, October 2017

document images. The author proposed a pre-processing procedure using a low-pass wiener filter, a rough estimation of foreground regions. The background surface is calculated by interpolating neighboring background intensities, a thresholding by combining the calculated background surface with the original image. Image up-sampling and post-processing step in order to improve the quality of text regions and preserve stroke connectivity.

Jagroop Kaur et al., [5] proposed a new algorithm for reliable methodology to enhance the proposed method using nonlinear enhancement method. The main limitations and benefits are identified for noisy and low intensity images. The main objective of this paper was the evaluation of algorithms and to find the short comings of algorithms for the degraded image binarization.

J. Sauvola et al. [6] proposed a new method called adaptive document image binarization, where the page is considered as a collection of sub components such as text, background and picture. The problems caused by noise, illumination and many source and different degradation methods. Two different algorithms are used to determine local threshold for each pixels. Large image data sets are considered for experimentation.

Mayur Sonar et al.,[7] described an adaptive image contrast based document image binarization technique that can be tolerant to different types of document image degradation such as uneven illumination and document smear. The proposed methods make the local image contrast and evaluation is based on local maximum and minimum. It combines local image contrast and the local method is tolerant to text and background variation caused by different types of document degradations.

3. BINARIZATION METHODOLOGY

3.1 Methodology

3.1.1Otsu method

Otsu method converts gray scale image into bi-level image. This method separates the pixels into two different classes one is foreground and another one is background. It chooses an optimal threshold that separates the images into two different classes [7]. Two parameters are used for selecting the threshold; they are minimum value in the within-class range and the maximum value in the within-class-variance. The weighted within-class-variance of two classes are calculated by using the given equation (1).

$$\boldsymbol{\sigma^2 p(t) = p_1(t)\sigma_1^2 + p_2(t)\sigma_2^2(t)} \text{ …….. (1)}$$

whereas (σ^2) is within-class variance, σ_2^2(t) is between-class variance, where the class probabilities of different gray-level pixels. Otsu method gives better performance for only images to have plain bi-modal pattern. But, degraded documents normally don't have such clear-cut pattern [17]. Besides this, it does not perform well for images with uneven illumination and shadow.

3.1.2 Niblack Method

Niblack methods have different threshold value and it is calculated for each and every pixel. It uses local information of the image, similar as variance, different range to calculate the threshold [16]. In this method a rectangular window slides above the gray scale image is used to calculate threshold of the pixels. It uses the local information mean and average difference of the window to calculate the threshold.

$$\boldsymbol{T_{Niblack} = m + k * s} \text{ …….. (2)}$$

$$\boldsymbol{N_{Niblack} = m + k\sqrt{\frac{1}{NP}\sum(p_i - m)^2}} \text{ …….. (3)}$$

Whereas m is the mean of local area pixels of an image and s is the standard deviation, n denotes local pixel area. The value k is a constant and it defines the size and quality of binarization. As this method is dependent upon the local features of the image, it gets affected by blank areas in the image and is also not efficient for the images with background noise.

3.1.3 Sauvola Method

Sauvola method is an advance technique of the Niblack method. It is a local variance method that uses for average distance. Threshold is calculated by using the formula given in equation 4.

$$\boldsymbol{T(i,j) = \mu * [1 + k\frac{\sigma}{R} - 1]} \text{ …….. (4)}$$

Whereas μ is the mean and σ is the standard deviation of the window. Values recommended for k and R is range from0.5 and 128 [9][11]. The window size and value of k will affect the quality of image but R will have very little affected. This method is used for documents having uneven illumination, light texture and stained documents. But, Sauvola method thins the text after its

application.

3.1.4 Nick Method

Nick method is an advanced method of niblack method where it plays very well for most degraded document. This method solves the problem of noisy images in white pages and low contrast problem [10]. The main aim of nick method is to solve the problem of black noise in the niblack binarization method and also helps the low contrast image by shifting the thresholding value downward. The thresholding formula

$$T(i,j) = m(x,y)[1 + k(\frac{\sigma}{R})] \text{..... (5)}$$

Whereas K is a factor of range [-0.1,-0,-2], pi is the pixel; value of gray scale image, NP is the total number of pixels, and m is the mean value.

3.1.5 Hybrid method

The proposed method is a hybrid-based technique. The image is logically partitioned into four rectangular parts. This method utilizes the model of minimizing within-class variance for calculating threshold in each partition that have two sharp peaks in the gray scale histogram[8][15]. The histograms of an image have varied intensities values of different pixels in the gray scale images. The ranges of intensity values in gray scales images are 0 and 255, where 0 represents black and 255 represents white pixels.

$$T_{(i,j)} = \frac{i_{low} + j_{high}}{2} \text{..... (6)}$$

$$T_{hybrid} = m + k \text{..... (7)}$$

$$T = m + k\sqrt{\sum \frac{pi^2}{NP} - m} \text{..... (8)}$$

Whereas T is threshold value, K is a factor of range [-0.1,-0,-2], p is the pixel value of gray scale image, NP is the total number of pixels, and m is the mean value of two images.

3.1 PSNR

PSNR is used to check the relationship between two images. It is used for images having noise. PSNR is calculated by using the given formula (9)

$$\text{PSNR} = 10log10\frac{C*C}{MSE} \text{..... (9)}$$

Where C is a constant and MSE (mean square error) describes the difference between the distorted image and the original image 13]. The value of PSNR should be more for better results.

3.2 NRM

NRM is calculated using the unmatched pixels between binarized image and original image [11]. It combines the false negative and false positive rate of Negative Rate Metric is calculated using the given equation (10).

$$NRM = \frac{NR_{FN} + NR_{FP}}{2} \text{..... (10)}$$

Whereas NR_{FN} the rate of is false negatives and NR_{FP} is the rate of false positives. Lesser the value of NRM is considered as better result.

Image name	Image type	Otsu		Niblack		Nick		Sauvola		Hybrid	
		PSNR	NRM	PSNR	NRM	PSNR	NRM	PSNR	NRM	PSNR	NRM
Image 1	JPEG	17.33	5.70	16.60	7.09	16.76	7.88	15.40	6.49	19.56	3.71
Image 2	PNG	18.51	6.89	15.73	9.06	17.15	9.77	15.69	5.31	20.21	4.59
Image 3	TIFF	16.84	5.99	11.89	5.91	11.85	8.88	13.90	9.99	19.92	6.03
Image 4	BMP	17.75	4.12	13.89	8.85	12.90	6.88	11.14	8.52	21.18	3.33
Image 5	GIF	19.09	6.33	18.03	9.67	17.44	5.96	16.85	9.03	17.84	5.99
Image 6	JPG	15.35	4.55	13.47	10.86	15.56	4.56	12.89	6.66	18.65	4.08

Table 1: PSNR and NRM values for Existing and Proposed method

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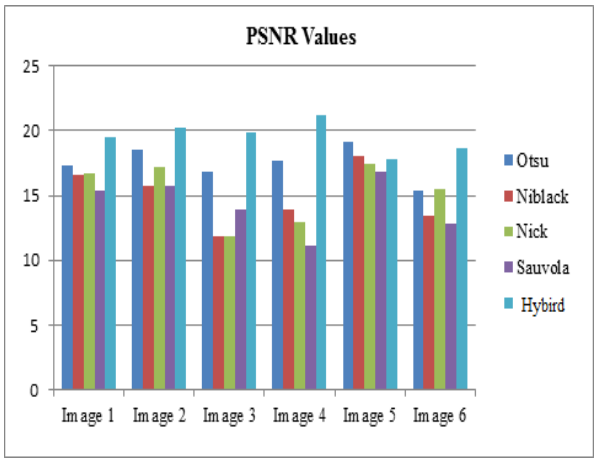


Fig 1: PSNR values for Existing and Proposed method

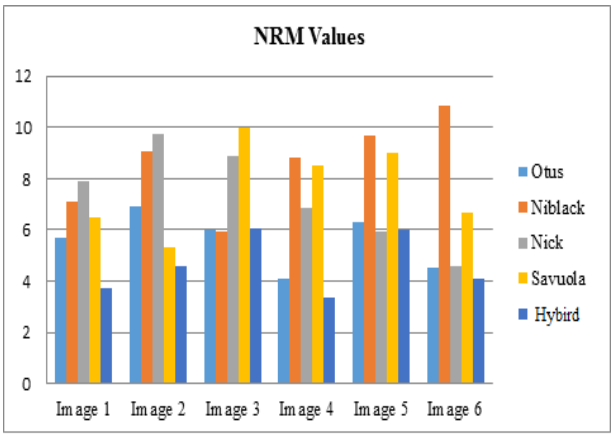
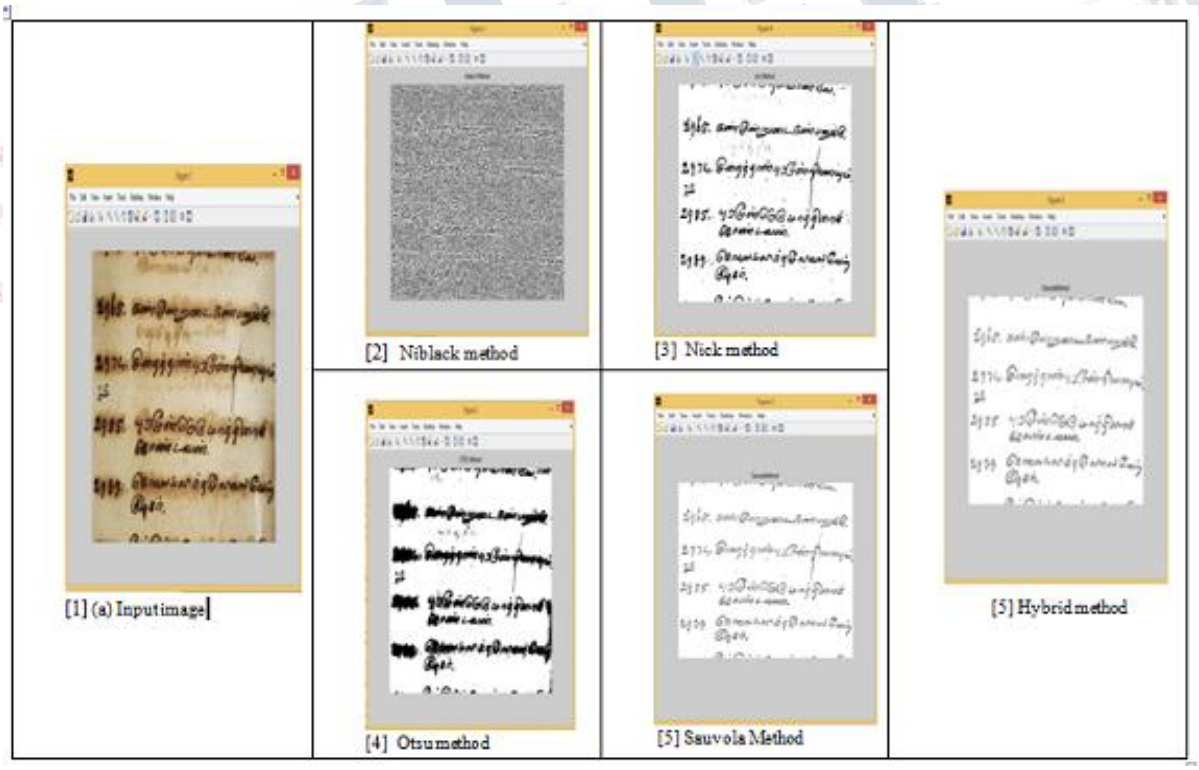


Fig 2: NRM values for Existing and Proposed method

3.3 Sample Outputs

3.3.1 Output for Tamil degraded document – Image1.JPG



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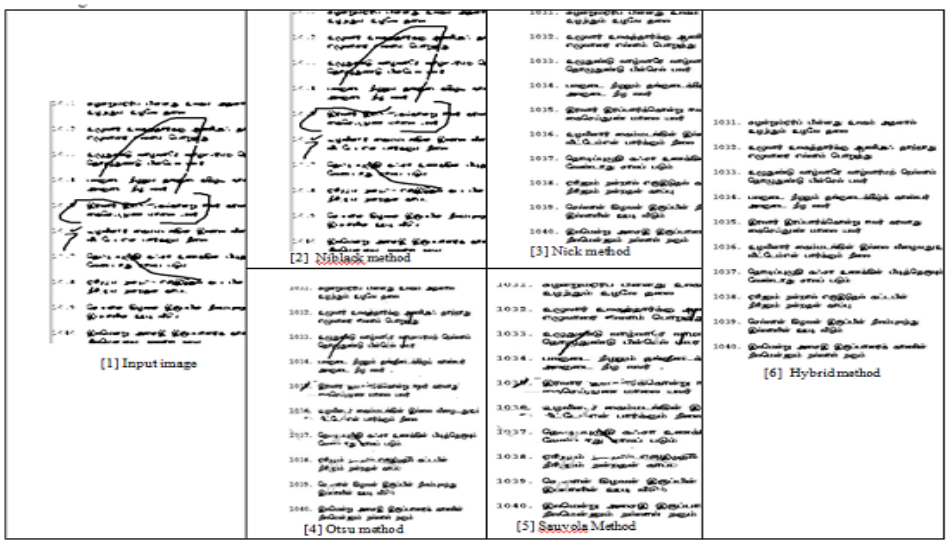
Vol 4, Issue 10, October 2017

3.3.1 *Image2 .PNG*



3.3.2 *Image3 .TIFF*

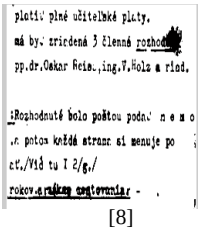
ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 10, October 2017

3.3.2 Output for English degraded document

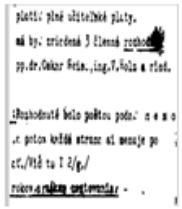
3.3.4Image4 .BMP

[1] Input image

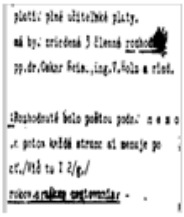


[8]

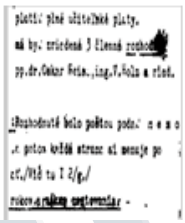
[2] Niblack method



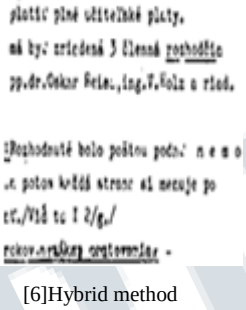
[3] Nick method



[4] Otsu method



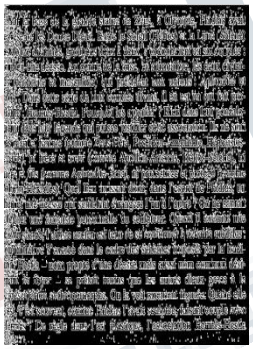
[5]Sauvola Method



[6]Hybrid method

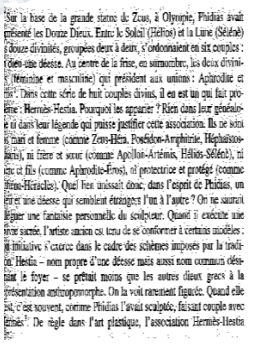
3.3.5 Image5 .GIF

[1]Input image



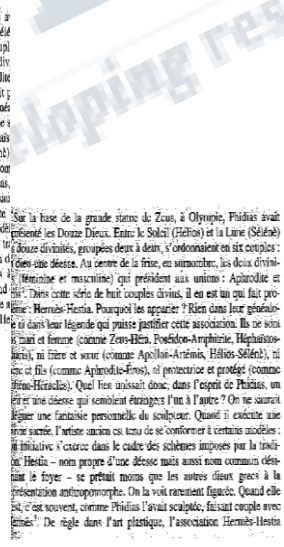
[2] Niblack method

[3] Nick method



[4] Otsu method

[5] Sauvola Method



[6] Hybrid method

CONCLUSION

In this paper we have proposed a hybrid binarization approach which aims to remove the background noise from historical and degraded documents. We combine the advantages of global and local thresholding because it has given better flexibility of various kinds of noise at different areas of the same image based on low computational cost and time. The proposed method requires multiple values by the user and deals with degradations which occurs due to shadows, non-uniform illumination, low contrast, and low pass images, smear, strain image. In future, new techniques.

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