International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Hybrid Method for Elimination of Uneven Illumination from Camera-based Document Images

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Abstract*: In this paper, is addressed the issues of uneven lighting and complex background of the camera-based document image using hybridization of new split and merge method. The input image is divided into four uniform size sub-images, and CLAHE enhancement technique was applied to all four sub-images to rectify noise amplification in each part of input image and then adaptive document binarization operation was used on four sub-images. Then, all four sub section images are merged to get the binarized image with elimination of noises, uneven illumination. Encouraging results are obtained by this method as compared on to other existing methods of Sauvola, Feng and Kasar found in the literature. The comparative analysis is made on collected datasets, as the standard datasets are not available.

***Keywords* : CLAHE, Binarization ,Otsu, Sauvola.**

I. INTRODUCTION

In current scenario, the majority of people groups are utilizing advanced cells and it needs quick improvement of the portable innovation which impacts to the living system of the individuals to capture the documents. Preprocessing of the content from camera caught scene pictures is challenging task due to its variety in images, possible distortions for instance, uneven lighting, low contrast and complex background which makes it increasingly hard to extract/recognize the text content. To carry the answer for the said difficulties this proposed strategy is useful. This newly proposed method divides the frame into four equally sized sub-images and applies the contrast-limited adaptive histogram equalization (CLAHE)[1] to the sub-images. These sub-images utilized to perform the binarization using the adaptive method. Finally, four sub-images are merged to form a fully binarized image. The purpose for splitting the image into four parts is to obtain uniform illumination in the camera-based document images.

The uneven lighting may be present in any section of document image; hence, the global threshold method may not be able to produce pleasing results.

Revised Manuscript Received on January 30, 2020.
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This is the only limitation for setting a threshold for the entire image. In view of this an experiment carried out to overcome the limitations by considering the adaptive threshold technique. The result of adaptive binarization is enhanced to a large extent by considering the CLAHE extended sub-images.

The paper has 5 sections. Section-2, contain literature on previous work carried out. Section-3 has the proposed methodology, Experimental results and discussions is given in Section-4. Section-5 has conclusion and future work.

II. LITERATURE REVIEW

This literature presents, the binarization is performed either globally or locally. In the global threshold single value for full image and in local threshold the adaptive values are considered. This literature review contains brief details on relevant articles about the elimination of uneven illumination and enhancement of documents taken with the camera.

Chien-Hsing Chou et al.[7] have divided the information picture into a few regions, and for each region, they have decided the t value for threshold binarization. They devised rules to make the binarization from the learning process. Test Images generated under normal and uneven lighting conditions are used as test images and claimed that test images provide good visual quality and performance in OCR.

Jung Kim [8] has designed the system to make binarizing camera images for document recognition utilizing numerous windows in an alternate size. They have applied several windows to the sample input image choose the local thresholds. This method preserves details of the character structure better and absorbs noise. They have achieved the recognition rates for set1 containing well-focused 141 images and set2 containing 72 not focused images with the 96.15%, 85.71% for 99.35% and 96.71% results respectively.

The adaptive binarization technique has been employed in Syed Saqib Bhukhari [9] has done binarizing hand-held camera captured documents. The multi-oriented and multi-scale anisotropic Gaussian smoothing is implemented for ridge detection to estimate the foreground regions of the grayscale document image. Their method suffers from time complexity in approximating the foreground regions, before applying the local binarization method. They presented overall average recognition accuracy in FMeasure of 91.67%.

The AMFBA (Adaptive Median Filter based binarization Algorithm) has been proposed by Xianfa Chenet al.[10], for camera based document binarization.

Selection of window size in AMFBA is obtained by computing the window size and variance in each pixel and largest variance is calculated by using size*size of the window. If the variance V is less than the variance value then it increases the window size. Median filter is considered to apply on each pixel in the image

Scene text binarization and document images is proposed by Ranjit Ghoshal and Ayan Banerjee [11]. They have performed in three stages; firstly computing the variance of the matrix, secondly linking the broken edges(Boundary) by Canny edge detection and applying adaptive thresholding method for binarization. To using 5x5 sized window. They have reported the FMas89.50.

T Kasar,J Kumar and A G Ramakrishna[4] have developed the system for digitizing camera-based document images. Their method uses the edge-based method for connected components to determine the text components and performs the binarization for that text component individually. They used the image data to select the threshold for binarization, and no manual vote is required for thresholding. Their method is robust in dealing with the ambiguity of foreground and background polarity of intensity in the picture. Then they analyzed the edge box, which captures the characters regardless of size and color. Hence, they have performed the local binarization without using a window.

A compact advanced camera is utilized for removing shading and binarizing the document images in Daniel Marques Oliveira et al.[12].

Their method is capable to handle the different camera resolutions and lighting patterns without changing the parameter. The outcomes have demonstrated this technique is powerful for an variety of scenarios and retains the texture of the original document.

From top literature it is observed that the binarization is completed dependent on the picture region[7], block[13], and window[6],[8],[10],[11]. The proposed split and merge technique divides the sample input images into sub-images and re-joins the sub-images and it gives better performance for document analysis

III. PROPOSED METHOD

The target of this paper is to study the performance of the split and merge technique for binarization of the camera-captured text documents, containing the uneven illumination and complex background.

The motivation behind this splitting of the input image is that the document has the uneven illumination at some part of the image, under study the splitting of the image and applying the binarization method on the splitted sub-images may remove the uneven illumination only at that sub-image.

To split the image we have used the adaptive segmentation technique, this works on input image of any size and splits into four uniform sized sub-images.

On each sub-images the CLAHE method is applied to enhance the sub-images, on the ground of the enhanced image, the adaptive method is applied to obtain the binarization of input image.

Following Figure 1. shows block diagram of the proposed method.

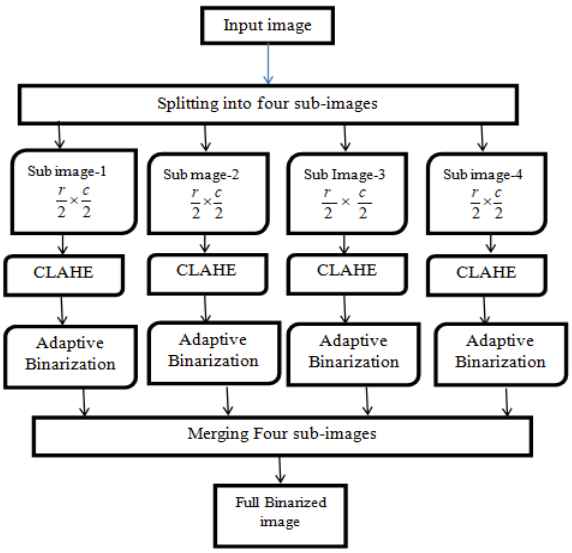


Fig 1.Block diagram of the proposed method

The above Fig1. Shows the block diagram of the proposed method, the input image is split into four uniform size sub-images. On four sub-images the CLAHE method is applied on the sub-images. The adaptive binarization technique is applied to four enhanced images. After the binarization, the merging process is carried out to obtain the full binarized image.

The following Figure2.shows the effect of CLAHE over the normal histogram equalization.

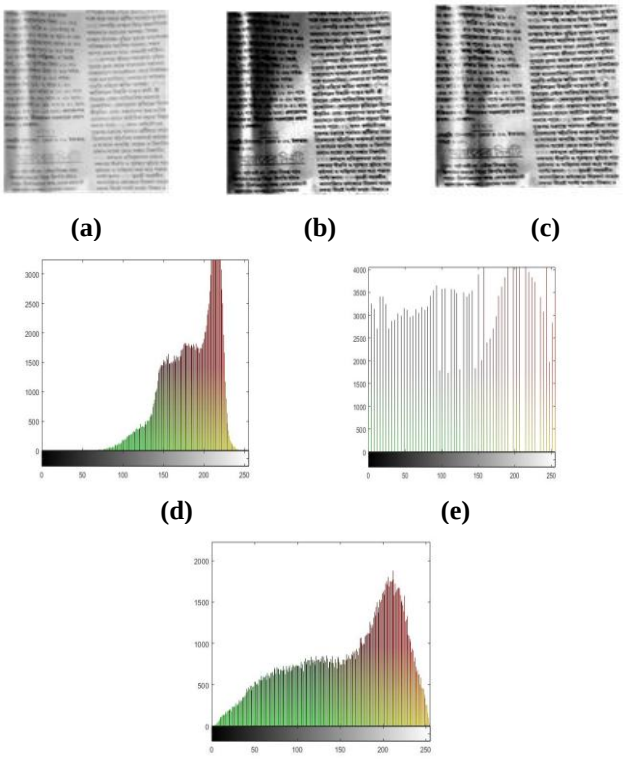
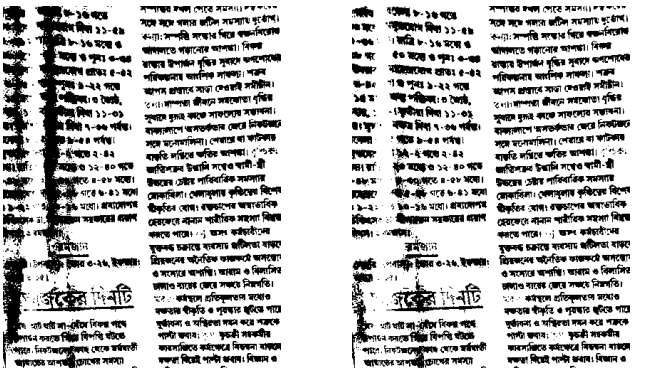


Fig2. Effect of CLAHE on the input image .(a)Input Image (b) Histogram equalized Image (c) CLAHE image(d) Input image histogram (e) Histogram equalized histogram (f) CLAHE histogram

The above Fig3. Shows the adaptive and non-adaptive histogram equalization result by using the input image. In the above figure, one can observe the difference between normal histogram and CLAHE image, the shadow presented in the normal histogram equalized image and in CLAHE image that shadow is removed. Due to the local adaptive histogram nature this CLAHE method was considered.

The following figure 3. Shows the binarization with normal histogram equalized image and CLAHE image.



(a) (b)

Fig 3: Image binarization of normal histogram equalized image and CLAHE image (a) Normal histogram equalized image binarization (b) CLAHE image binarization

By observing the above Figure3. The CLAHE method is adopted to the proposed method to get the clear text component from the camera captured input image.

Proposed split and merge Algorithm

Input: Document Image.

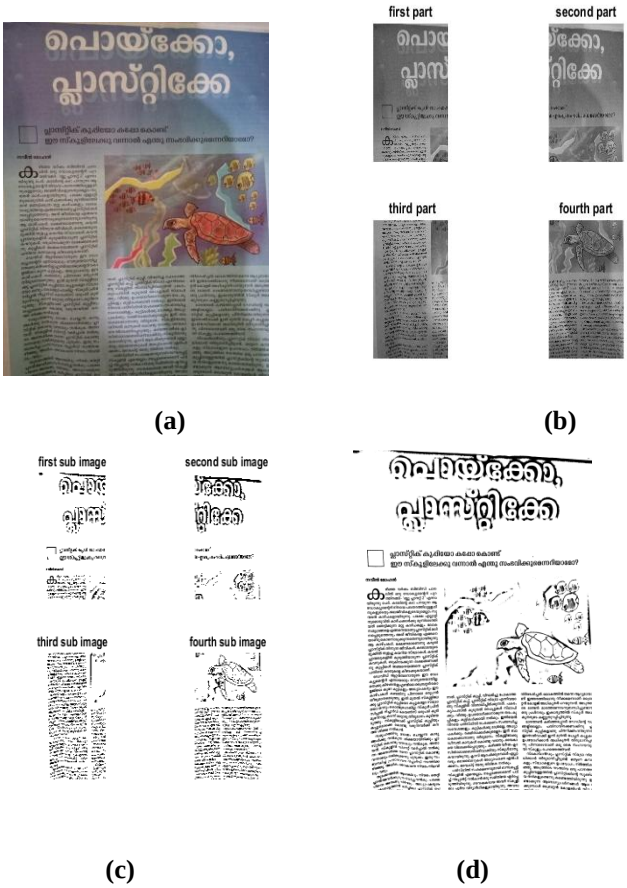
Output: Binarized Image.

Step 1: Start
Step 2: Read the input image.
Step 3: Perform the splitting the input image into four uniform sub-images
Step 4: Apply the CLAHE image enhancement method to each sub-images.
Step 5: Apply the adaptive binarization method to each sub-images.
Step 6: Merge the four binarized sub-images in a manner splitting is performed to obtain the full
Binarized image.
Step 7: Stop.

IV. EXPERIMENTAL RESULT AND DISCUSSION

To test the performance of the proposed method, we have collected different kinds of color document images containing the Book covers, Newspapers, Magazines, Calendars, Fiction and Non-fiction novels etc. The images containing blur, uneven illumination, complex background, low contrast, noises are selected for experiment.

Following Fig4. Shows the functional diagram of the proposed method. This diagram represents the flow of process to eliminate the uneven illumination according to the proposed method.

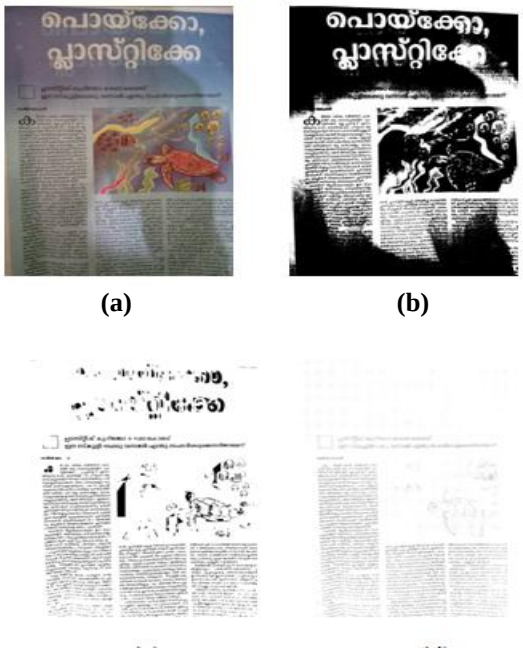


(a) (b)

(c) (d)

Fig 4. Process of elimination of uneven illumination from camera based document image (a) Input image (b) Split into sub-images (c) Binarized sub-images (d) Merged image

In the following Figure 5, comparison of image is made with other popular binarization methods applied on one sample input image to exhibit the significance of proposed method.



(a) (b)

(c) (d)

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

(e) (f)

Fig 5. The comparison of the proposed method with other methods. (a) Input Image (b) Otsu's method (c) Kasar method (d) Feng method (e) Sauvola method (f) Proposed method

Figure 5 shows the performance method proposed by other common methods. We can clearly see that the other binarization methods did not perform well and the proposed method gave the best performance of its kind. In the Sauvola method, the big characters are lost and the other small characters are very thin. In the proposed method, the larger characters are shown the shapes of the characters and other small characters are thick. Otsu and Kasar methods performed poor. Other methods show the thicker characters, but another part of the picture is lost. Feng method is given very low contrast of the input image. Hence, the proposed method is good in preserving the shapes of text components in the camera caught document.

4.1. PERFORMANCE EVALUATION METRICS

To analyze the effect of the proposed method the F-Measure, MSE, and PSNR are computed by using following formulas.

1.**F-Measure**: This is balanced mean of precision and recall. It is described as the weighted harmonic mean with precision (p) and recall(R). The highest value of F-Measure represents the better result and it is defined as

$$F = \frac{1}{\alpha\frac{1}{p} + (1-\alpha)\frac{1}{R}} \qquad (1)$$

where the weight $\alpha \in [0,1]$

2.**Mean Square Error(MSE):** This MSE measure is useful in computing the error between the input and reconstructed image(un-even illumination removed image).The low MSE is represent the better result. The MSE is defined as

$$MSE = \frac{1}{M \times N}\sum_{m=0}^{M-1}\sum_{n=0}^{N-1}(f(m,n) - g(m,n))^2 \qquad (2)$$

where the f(m,n) is original image and g(m,n) is reconstructed image.

3. **Peak Signal-to-Noise Ratio (PSNR):** This is given in dB's and it is superior in other measures by using the following equation. The PSNR should be as high as possible

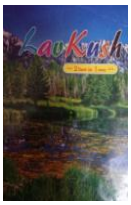
$$PSNR = 20 \times \log\left(\frac{MAXi}{MSE}\right) dB \qquad (3)$$

where the maximum intensity of the image is given by MAXi is the highest intensity value i.e.,255 and it is commonly described in the terms of logarithmic decibel(dB)scale

The performance evaluation of the method compared with other popular binarization methods.

Table1.shows the performance of the proposed method with other popular methods using the above metrics

Table1.Comparative analysis with proposed method result with Kasar, Feng, Sauvola methods.

Sl. No.	Input image	Methods	F-Measure	PSNR	MSE
1		Kasar	20.32	2.58	0.55
		Feng	09.68	2.42	0.57
		Sauvola	31.81	3.09	0.49
		Proposed	**57.9**	**4.38**	**0.36**
2		Kasar	18.96	3.18	0.48
		Feng	33.91	3.9	0.40
		Sauvola	56.57	5.15	0.32
		Proposed	**73.08**	**6.54**	**0.22**
3		Kasar	0.94	1.09	0.77
		Feng	31.46	2.09	0.61
		Sauvola	25.64	1.86	0.65
		Proposed	**58.34**	**3.34**	**0.46**
4		Kasar	41.1	4.69	0.33
		Feng	12.51	3.91	0.4
		Sauvola	64.74	6.42	0.22
		Proposed	**74.39**	**7.20**	**0.19**
5		Kasar	15.68	3.52	0.44
		Feng	0.75	3.64	0.43
		Sauvola	0.81	3.83	0.41
		Proposed	**54.23**	**5.20**	**0.30**

It shown from Table.1 proposed method produces relatively better results for different types of distortions, such as uneven lighting, complex color background and low contrast. Therefore, it is noted that the proposed method is robust to the distortions of the image taken by the digital camera.

V. CONCLUSION

To obtain the clean data for better performance, an attempt is made by proposing a method to eliminate possible image distortions such as uneven illumination,

low contrast, shadow effect this method proposed in this paper contributes for quality input image to obtain the reliable recognition results. The fair comparison is done using other popular methods and the proposed method is surpassed by other methods. In the next work we consider other types of images which are degraded images such as degraded handwritten historical document images for enhancement.

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