

A Hybrid-Binarization Approach for Degraded Document Enhancement

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Abstract

Images get degraded because of unbalanced enlightenment including text-smearing, ink-bleeding, degradation of ink over time, manuscript characters from background coming out and blended with the characters of the main side etc. So, degraded-document enhancement is a challenging issue. In recent years, several binarization approaches are proposed to enhance these images. These techniques have focused on finding a suitable global threshold value or a local threshold value for every region to eliminate the degradations. A hybrid approach can be a good solution to deal with all these matters together. This paper proposes a hybrid approach of binarization for degraded documents to produce better quality result. Then, the performance of the proposed technique is evaluated using DIBCO 2010 to DIBCO 2018 databases and compared with the existing methods which confirmed that the proposed method is robust, efficient. Finally, a direction towards future works and challenges is stated.

Keywords

Degradation, Enhancement, Hybridization, Image Manuscript, Thresholding, Binary Image

1. Introduction

There are numerous old and historical documents and manuscripts which are stored in libraries and archives. These documents have essential information about the heritage of human. Different ecological issues, inappropriate management and bad-quality materials of the paper degraded these documents [1] [2] [3]. So, the analysis on the degradation of manuscripts is a challenging area for researchers nowadays.

Binarization is the primary step of analyzing documents. It is a technique of conversion from grayscale or into a binary image. The consequent steps are vastly reliant on the accomplishment of binarization and the success of binarization can affect the preservation of the significant information of the degraded documents.

There are different types of binarization approaches which contain several advantages and drawbacks. So, it is very demandable to develop a quick, ideal and appropriate method for every degraded document [4].

The core principle of this research is to offer an image binarization technique to satisfy different purposes. It attempts to unite the benefits of local and global thresholding.

Our paper is structured as follows: In Section 2 we have illustrated literature review. Section 3 presented our proposed binarization technique briefly. In Section 4, the performance evaluation is briefly described. We have discussed the advantages of the proposed method in Section 5 and conversed about the future works and challenges in Section 6. Finally, in Section 7, we have concluded the paper along with some future research directions.

2. Literature Review

In recent years, many researchers worked on binarization techniques. A complete evaluation on image binarization along with some noble and benchmarked binarization methods are presented below:

Lu *et al.* [4] presented a contrast-enhancement based thresholding technique. They focused on the difference of the contrast of grayscale image in different regions of input image.

Mollah *et al.* [5] presented a binarization method for the images of business cards. Based on intensity-variance, a card image is separated into small blocks which can be extracted from background. The areas without text are removed and the texts are exacted and thresholded by applying a local adaptive method.

Darek Bradley *et al.* [6] proposed a vigorous and simple binarization technique which depends on spatial variation in illumination.

Badekas *et al.* [7] presented a binarization technique for color pictures where texts are mixed with the background.

Otsu [8] presented a global thresholding technique. It can convert grayscale images to bi-level images and can divide the pixels into background and foreground divisions. The Otsu's technique works well with the images with bi-modal model.

Sauvola [9] presented another procedure which uses standard deviation to find out the threshold value. It is an upgraded version of Niblack's technique.

Nick *et al.* [10] presented local thresholding technique. In this process, the value of thresholding is moved downward to eliminate noise and to lessen the contrast problem.

Shafait *et al.* [11] proposed local adaptive thresholding technique. Local adap-

tive thresholding is used for local binarization. A window of size $N \times N$ moves over the whole picture and a thresholding value is calculated for every local region. This technique provides ideal outcome with the images affected by low resolutions, blurring and non-uniform illumination etc.

However, different researchers presented different methods for the enhancement of degraded documents. But all these methods have some benefits along with some drawbacks. So, a vigorous binarization technique which is applicable on any degraded document for the enhancement is still in high demand to develop.

Through these observations, in this paper, we have presented a hybrid technique with the desire of better output with proper enhancement. Our technique presents a robust binarization approach where we hybridized some thresholding methods to get better result than any other approach.

3. Proposed Methodology

The binarization method is used as the main part in different analyses of documents. On the other side, the method must be simple and suitable for every document analysis. **Figure 1** shows the flowchart of the steps of the proposed hybrid-binarization technique.

The steps of the proposed binarization technique are detailed and explained below:

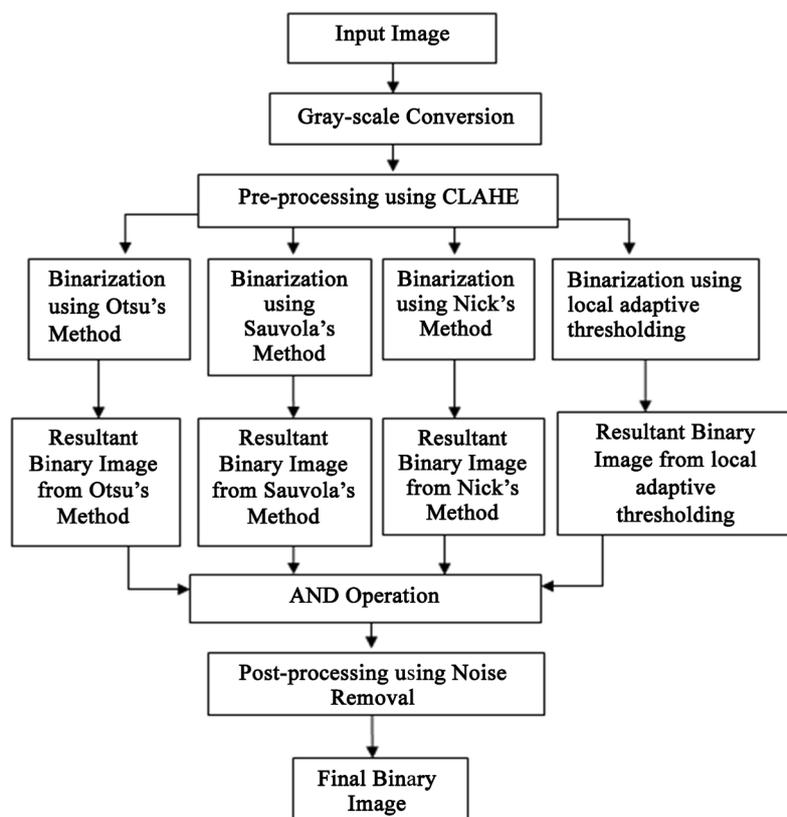


Figure 1. Proposed hybrid-binarization technique.

3.1. Inputting Image

Inputting image is the initial step of this procedure. Images are captured by camera or obtained by using secondary sources such as scanner.

3.2. Converting to Gray-Scale Image

After completing the above step, we need to verify the image to know the format of the image. When the inputted image is in RGB format then the image will be transferred into grayscale format. But, if the image is in grayscale, then it will be preprocessed in the next stage.

3.3. Preprocessing

The preprocessing step is the next stage for the grayscale image. Generally, preprocessing is required to eliminate the imperfections of the input-image. This step facilitates the hybridization step. The contrast of the grayscale-image is made better and enhanced by applying CLAHE (Contrast Limited Adaptive Histogram Equalization). In each segment of the image, it improves the local contrast and restricts the amplification of noise.

3.4. Hybrid-Binarization

After grayscale enhancement, we go through a hybrid thresholding technique by uniting four ideal methods: Otsu's technique, Sauvola's technique, Nick's method and local adaptive thresholding technique.

Otsu's technique performs best for the images with apparent bi-modal model and Sauvola's technique makes enhanced outcome with least amount of noise and but it is not able to differentiate text with very low-contrast and illuminated-texture.

Local adaptive technique gives perfect result for the images which are affected by low-resolution, shading, and blurring. Nick's method performs very well in dealing with noise. So, considering the advantages of these methods, we combined these techniques for binarization to get better performance.

3.5. Post-Processing

The binary image will go through post-processing. We have done noise removal operation for the enhancement of the document.

4. Experimental Results

For evaluating the performance of our technique, we have done some simulations using the datasets of DIBCO-2010 to DIBCO 2018 which include handwritten and printed documents. In addition, the proposed method is compared with some standard binarization techniques, such as Otsu's, Savoula's, Nick's, and local adaptive thresholding methods on the basis of accuracy rate and computation time.

In **Figure 2(a)**, the inputted image is taken from DIBCO-2010 database, in

Figure 2(b), we presented the resultant image produced from Otsu’s method, in **Figure 2(c)** we depicted output from the Sauvola’s method, in **Figure 2(d)**, we have shown the outcome of Nick’s technique, in **Figure 2(e)**, we demonstrated the result of local adaptive thresholding method and in **Figure 2(f)**, we depicted the result of proposed method.

We have completed similar actions in **Figures 3-9** for the images collected from DIBCO-2011 DIBCO-2012 DIBCO-2013, DIBCO-2014, DIBCO-2016, and DIBCO-2017 and DIBCO-2018 datasets respectively.

We have also publicized the accuracy rate and computation time for the

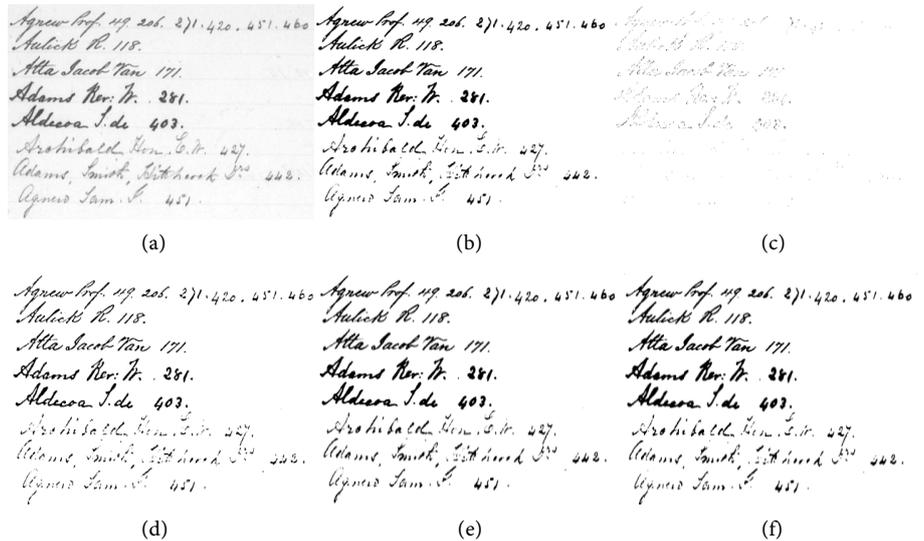


Figure 2. (a) Inputted image (DIBCO 2010); (b) Result of Otsu technique; (c) Result of Sauvola’s technique; (d) Result of Nick’s technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.

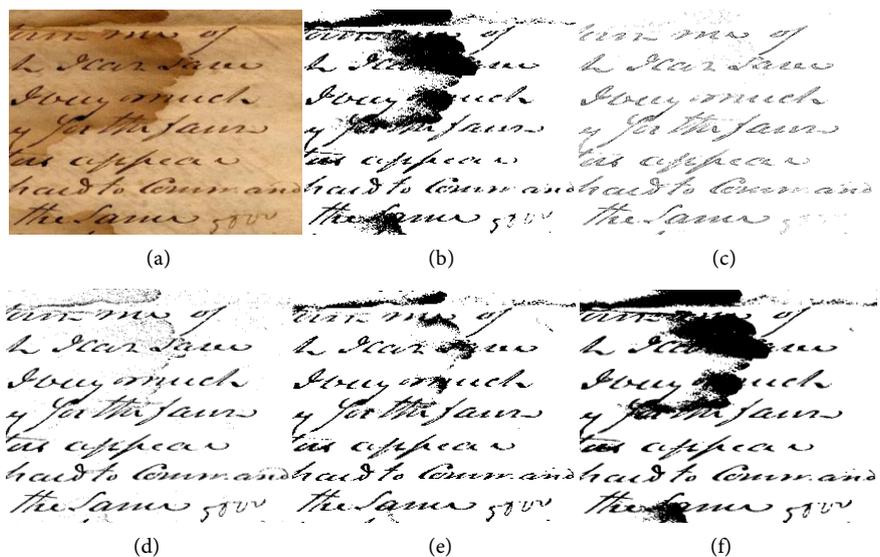


Figure 3. (a) Inputted image (DIBCO 2011); (b) Result of Otsu technique; (c) Result of Sauvola’s technique; (d) Result of Nick’s technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.

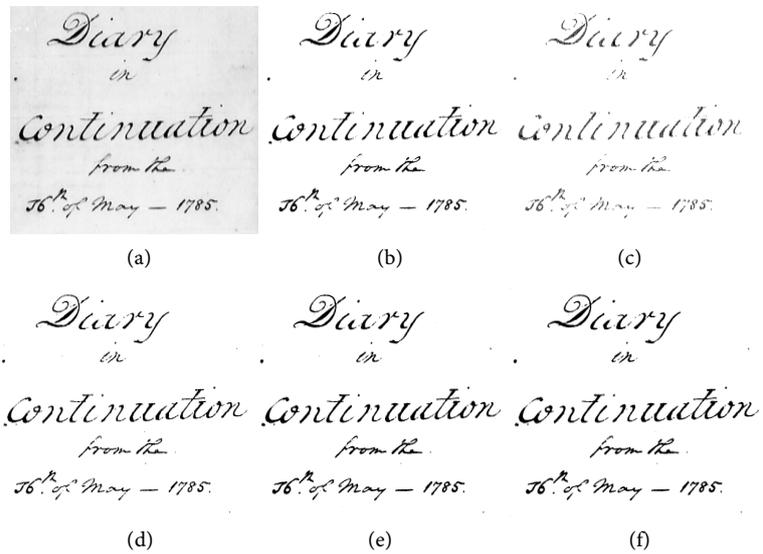


Figure 4. (a) Inputted image (DIBCO 2012); (b) Result of Otsu technique; (c) Result of Sauvola's technique; (d) Result of Nick's technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.

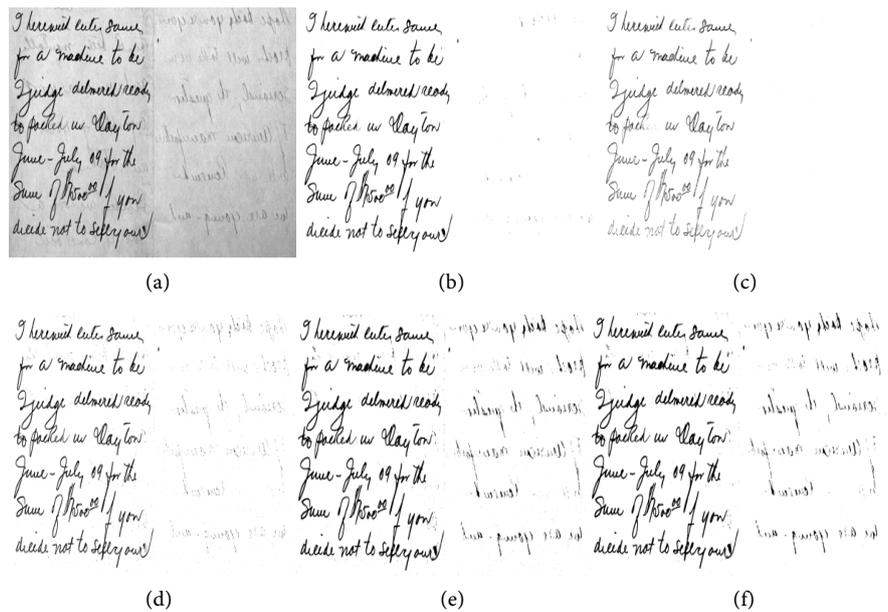
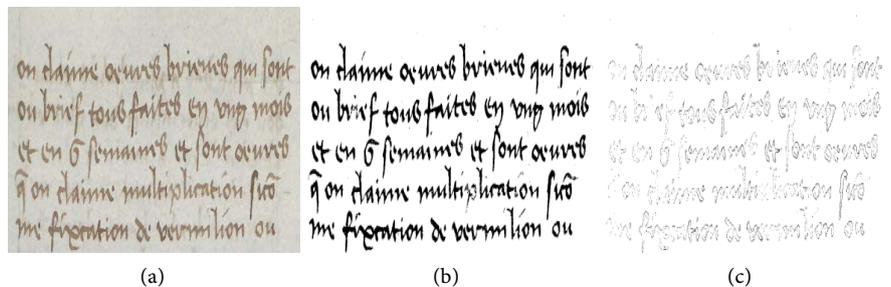


Figure 5. (a) Inputted image (DIBCO 2013); (b) Result of Otsu technique; (c) Result of Sauvola's technique; (d) Result of Nick's technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.



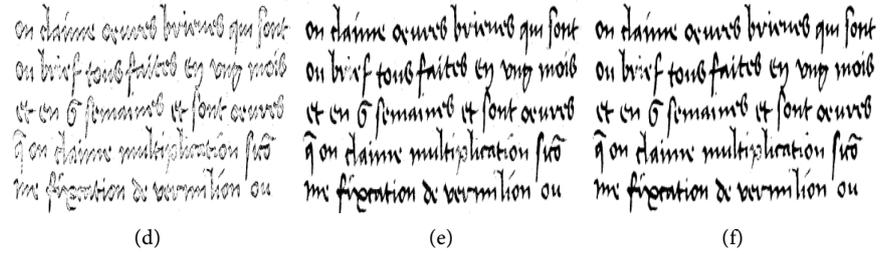


Figure 6. (a) Inputted Image (DIBCO 2014); (b) Result of Otsu technique; (c) Result of Sauvola's technique; (d) Result of Nick's technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.



Figure 7. (a) Inputted image (DIBCO 2016); (b) Result of Otsu technique; (c) Result of Sauvola's technique; (d) Result of Nick's technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.



Figure 8. (a) Inputted image (DIBCO 2017); (b) Result of Otsu technique; (c) Result of Sauvola’s technique; (d) Result of Nick’s technique; (e) Result of local adaptive thresholding; (f) Result of proposed technique.

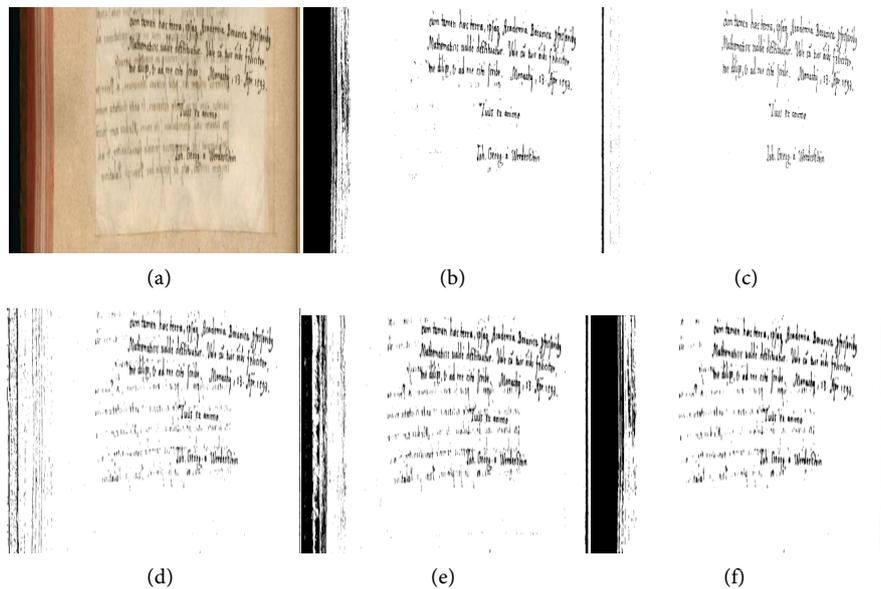


Figure 9. (a) Inputted image (DIBCO 2018); (b) Result of Otsu technique; (c) Result of Sauvola’s technique; (d) Result of Nick’s technique; (e) Result of local adaptive thresholding; (f) Result of proposed method.

evaluation of the results in **Table 1**. We have applied the following method to compute the accuracy A:

$$A = 1 - \frac{\text{sum}(\text{sum}(|IM_1 - IM_2|))}{\text{sum}(\text{sum}(IM_1))} \quad (1)$$

In Equation (1) [12], IM_1 is the original image and IM_2 is the output generated from proposed technique.

Table 1. Performance evaluation of the proposed technique along with different binarization techniques.

Datasets	Binarization Methods	Accuracy rate (%)	Time (sec)
DIBCO 2010	Otsu	99.41	1.87
	Local adaptive	99.33	1.11
	Sauvola	92.84	0.68
	Nick	97.51	0.65
	Proposed method	99.55	2.70
H-DIBCO 2011	Otsu	91.96	1.12
	Local adaptive	82.40	0.95
	Sauvola	74.15	1.06
	Nick	78.84	1.28
	Proposed method	92.22	1.78

Continued

H-DIBCO 2012	Otsu	99.96	1.24
	Local adaptive	99.25	1.96
	Sauvola	98.08	1.18
	Nick	99.43	1.57
	Proposed method	99.37	2.62
DIBCO 2013	Otsu	99.26	1.96
	Local adaptive	98.16	1.55
	Sauvola	97.76	1.18
	Nick	99.11	1.85
	Proposed method	99.65	6.95
DIBCO 2014	Otsu	98.72	1.25
	Local adaptive	98.68	1.11
	Sauvola	86.66	1.16
	Nick	92.52	1.14
	Proposed method	98.82	2.10
DIBCO 2016	Otsu	95.64	1.10
	Local adaptive	93.36	0.92
	Sauvola	77.89	0.85
	Nick	89.10	1.04
	Proposed method	95.69	1.48
DIBCO 2017	Otsu	98.24	1.25
	Local adaptive	98.43	1.21
	Sauvola	89.80	1.60
	Nick	96.63	1.64
	Proposed method	98.68	4.37
DIBCO 2018	Otsu	99.43	0.79
	Local adaptive	92.08	1.15
	Sauvola	85.50	0.82
	Nick	87.05	0.85
	Proposed method	97.59	2.09

5. Discussions

Therefore, the outputs show the robustness of our proposed technique. It is found that, our proposed method and Otsu's method have shown enhanced performance comparing to the other techniques because these two have shown utmost accuracy rate. The local adaptive thresholding gave somewhat good outputs. But, rests of the techniques publicized the comparatively lesser performance to these techniques.

6. Future Works and Challenges

We have presented a technique that combines the advantages of different binarization techniques such as global and local binarization. So, future researchers can focus on parameter tuning, noise removing, post-processing for qualitative binarization. The post-processing can reduce the performance by increasing the execution time but it can develop the quality of the manuscripts. Several filters could be used for noise problems and these filters could reduce black spots from the final image. In this way, we can preserve the important information of the degraded documents.

7. Conclusion

Historical documents hold important information of ancient times. High-quality techniques of binarization can recover the texts from the degraded document image. The earlier studies show that there is no efficient technique of binarization for diverse types of degraded document images. A variety of binarizations are used to enhance these degraded documents. So it is necessary to propose a quick and ideal technique of binarization which is appropriate for all kinds of degraded documents. We proposed a hybrid binarization approach to produce good quality image and attempted to merge the benefits of local and global thresholding methods. The experimentations over the datasets DIBCO 2010 to DIBCO 2018 confirmed that the performance of the proposed technique was superior in terms of the accuracy rate.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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