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Enhanced Document Binarization Technique for Image Processing

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ABSTRACT: Improvement of degraded document is the important topic now days for scientist. With respect to time there is occurrence of changes in appearance of documents which are in terms of document degradation. Document degradation is the slow process however; it may degrade more significant historical and important data recorded on paper. For aforesaid issue the process known as document binarization is playing a key role in the enhancement of document quality. In present paper, image document binarization process is carried out with the help of Niblack and Sauvola Technique. A series of various combinations of Niblack and Sauvola techniques are explored for first time. Interesting results are obtained in combination with hybrid technique. This modification in algorithm results in output in the form of graphical representation. In addition, the present system is capable to plot the output with PSNR values.

KEYWORDS: Image processing, Document analysis, Document binarization

I. INTRODUCTION

Storage of historical and important documents with prevention of contain for long time [1, 2] is quite difficult and challenging task. In ancient days, the technological development was not so far done and hence, these documents were written by hand. It is observed that, with respect to time degradation of these documents is serious issue. These documents have more significance and importance hence, their maintenance or transformation in rewritten form is not cheap. However, present digital technology has capability to overcome such issue with the help of smooth operations [3]. As the technological development occurs different type of techniques came forward for the transformation of hand written documents into the digital form [4]. In this competition, Optical Character Recognition (OCR) is playing an important role for access and storage the information in digital form [5]. The degradation of document is of no single type and hence total removal of all such degradations by OCR is not possible.

To overcome these issues related to document degradation various techniques come forward with solutions. In recent days, tremendous interest has grown for transformation of these old documents in the digital forms [6]. In present paper, more emphasis is given on the improvement of the quality of the texts and images associated in the document. A various combinations of Niblack and Sauvola techniques lead to more enhancement in the output. A detail and systematic study of enhancement in document binarization is well explained in the present paper.

II. RELATED WORK IN THIS FIELD

Various document binarization techniques have been summarizes in this section. One of the famous techniques known as Otsu's [7] was introduced a long ago. Global thresholding is the key part of this technique and is also found to be superior than other methods. Niblack technique in year 1986 was proposed by W. Niblack [8]. In this technique calculations of threshold are based on rectangular window movement taken place over gray level image. Noise present in the region of non text is the prominent drawback of this technique. Removal of such a type of noise is the crucial part and further techniques are required for removal of noise.

Sauvola has proposed most powerful technique and is known by Sauvola technique [9]. This technique works more prominently when the document is said to be illuminated unevenly and there is presence of large variations etc. Estimation of local threshold value is the fundamental principle of Sauvola method. Sauvola technique is not

recommended when requirement of process speed is high enough. A tailor made version operates on intensities of pixels has been proposed by Bernsen [10]. For local threshold lower and higher intensities values have been considered. Threshold value is generally fixed by optimizing the mean value of intensity of pixel. This method is known to be inappropriate for documents with compounded background. The LMM method came with the solution of above method [11]. Local image contrast and normalization factor are the important factors of this method. In fact, this method is not suitable for the bright background with bright text [11].

The development of technology occurs Gatos's [12] has resolved the problem associated with LLM method. A key factor of this technique is the calculation of background intensities. This method is simple and known for binarization process of document however; images with low resolution are not suitable for this technique.

Pai et. al. [13] in 2010 developed the scientific method for improvement of document. The binary image is formed by taking threshold value. This method is famous for the electronic devices.

III. PROPOSED WORK

Various image segmentation algorithms are present however, everyone has its own pros and cons. To overcome this issue we have implemented a system in such a way that pros of such a algorithm has been considered while cons have been removed. To attempt this, we have taken various combinations of well known technique 'Niblack' and another one is 'Sauvola'. All the possible combinations are discussed in detail.

1. Serial approach:

A) For this approach the degraded image is given as an input the system. After that, it is converted into gray scale image. The Niblack algorithm is works on the gray scale image. In this approach the pixel wise threshold is calculated by moving a rectangular window of different size over the gray level image. Niblack method is adaptive threshold method, but the main drawback of this method is that it produces a large amount of noise in the empty windows and some noises are also exist in non-text regions. To overcome this drawback further, Sauvola algorithm is applied on output image of Niblack. This approach calculates local threshold value using local mean and local standard deviation for each pixel separately. This method solved the problem of noise up to great level.
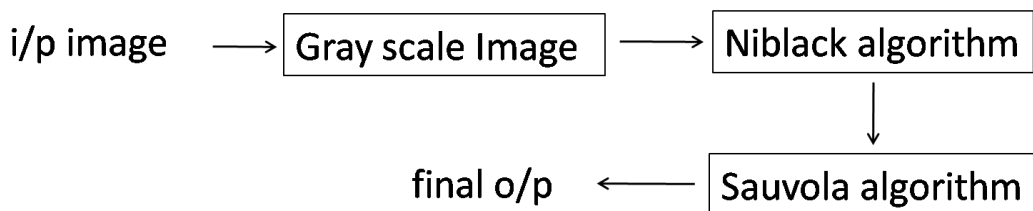

Fig.1. Work flow of Serial approach 1.

Niblack method:

The improvement of binarization for "white" and light page images is achieved by shifting down the binarization threshold which is the major advantage of this method [14]. The threshold is calculated:

$$T = m + k\sqrt{\left(\sum p_i^2 - m^2\right)\Big/NP}$$
$$= m + k\sqrt{A}$$

where,
k = Niblack factor
m = mean gray value
pi = pixel value of gray scale image
NP = number of pixels

Sauvola method:

A threshold at each pixel is calculated by Sauvola technique by considering grayscale image as a input [15].

$$T = m \times \left[1 + k \times \left(\frac{s}{R} - 1 \right) \right]$$

where,
k = user-defined parameter,
m and s = mean and the local standard deviation computed in a window of size ω
R = dynamic range of standard deviation (R =128 with 8-bit gray level images).

B) For this approach the degraded image is given as an input to the system. After that, it is converted into gray scale image and is given to the Sauvola algorithm. Then Niblack takes the output image of Sauvola and further, we get the final output.
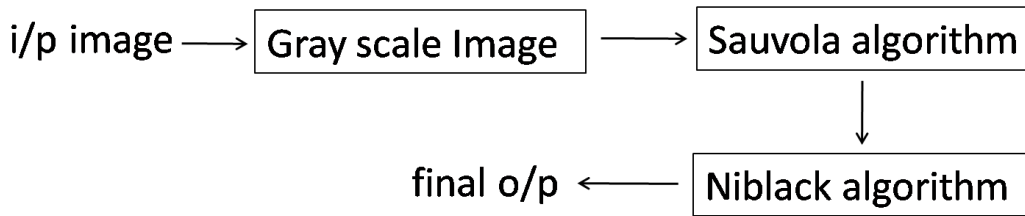

Fig.2. Work flow of Serial approach 2.

C. Hybrid approach:

In previous two approaches we took Niblack and Sauvola methods serially with alternative combination but now in this approach we will take both of these two methods parallelly, so that we will have their benefits separately. In this approach degraded image is given to both Niblack and Sauvola. Niblack run on text part on that given image however, Sauvola run on non-text part of that image. In fact, Niblack detect the text body effectively in case of low contrast image too. Effectively, Sauvola technique focuses on noise associated on non-text part of image. In Niblack method the pixel wise threshold is calculated by moving a rectangular window of different size over the gray level image. Niblack method is adaptive threshold method, but the main drawback of this method is that it produces a large amount of noise in the empty windows. Some type of noises are exist in non-text regions also. Sauvola method calculates local threshold value using local mean and local standard deviation for each pixel separately. This method gives improvement especially when the background contains light texture, big variations, stained and unevenly illuminated documents. It adapts the contribution of the standard deviation. This method solves the problem of noise up to great level. After working on textual and non-textual part separately, output of both methods merged in a single output image.
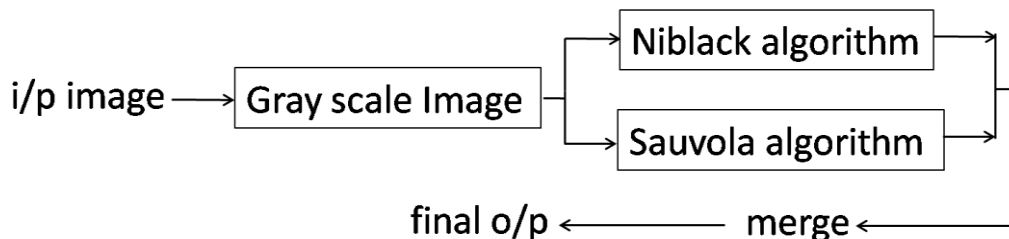

Fig.3. Work flow of hybrid approach.

III. RESULTS AND DISCUSSION

Here, we will discuss the obtained results in detail with their thorough analysis. Effectiveness of applied techniques with better solutions is the key aspect of this part. A variety of 15 images such as printed, noisy, low quality and complex are considered as input to our proposed techniques. The performance of the system is measured with the help of Peak Signal-to-Noise Ratio (PSNR). The PSNR is a measure of the amount of signal in an image with respect to the amount of noise available. The higher values of PSNR relate to better signal as compared to noise in image [16]. With respect to document binarization, PSNR provides a measure of the quality of binarization against ground truth image and it can be measured.

$$PSNR = 10 \times log_{10}\left(\frac{MAX_I^2}{MSE}\right)$$

where, mean square error (MSE) can be represented as below.

$$MSE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}\left(B_{(i,j)} - GT_{(i,j)}\right)^2}{N \times M}$$

The given graph is an output of performance of various techniques on input image. The performance is measured in terms of PSNR value. The individual algorithm of each technique has variance in PSNR value however if the PSNR value is higher then it is assumed to be better technique. In below graph different thresholding algorithms are implemented and are presented on x axis and PSNR values on y axis. A careful observation of given graph indicating that the hybrid approach has maximum PSNR value. Hence, the hybrid approach is found to be more suitable for the image document binarization.
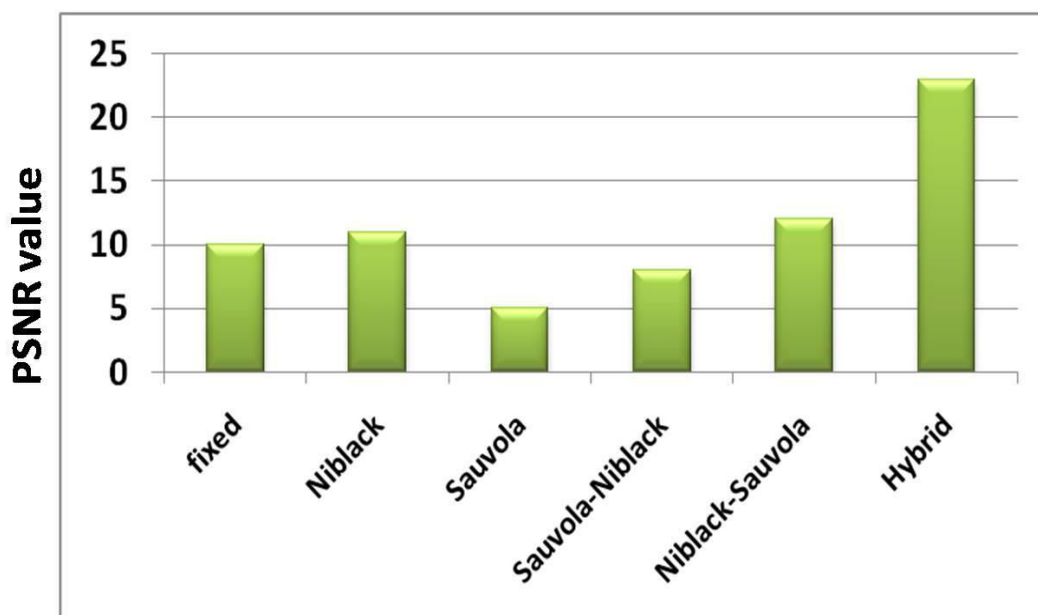
IV. CONCLUSION

The work related to image document binarization is presented in this paper. Various techniques have been discussed in detailed. More emphasis is given on the different approaches required to solve the various issues. A various combination of existing techniques leads to the variation in the output results. Initially, Niblack and Sauvola techniques have been performed individually. Further, serial approach has been adapted and then improvement in the PSNR value is observed. A proposed attempt was to improve the output in great extend hence, hybrid approach is defined and used further. A very drastic improvement in the PSNR value is observed which further indicates that the hybrid approach is much suitable for the degraded document binarization. The present work has high importance in the field of image binarization and will definitely catch the broad audience.

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