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Degraded Document Image Binarization Using Hybrid Thresholding techniques

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Abstract - Old documents are affected by affected by different degradation factors such as uneven illumination, smudging of text, ink seeping on another side, ink degradation. This parameter affects the originality of the document and it causes the loss of important information. In this system, the improved algorithm for Binarization of the degraded document has been proposed to retrieve the original information from the old degraded documents. Firstly the degraded document image is digitalized by scanning the document. Contrast image constructed by combination of local image gradient and local image contrast. Further canny edge detection is applied to find out edge strokes and unwanted edges removed by applying Otsu thresholding. Finally, process image is post processed through toggle filter. ***The proposed system tested on DIBCO database. The system achieves 99.02% accuracy and 99.50% F_Measure score.***

Keywords —Binarization, degraded document image, old script images, local image contrast, local image gradient, thresholding

I. INTRODUCTION

Welcome In society, the strong median of storing information is a document. Most of the offices use papers for documentation. These documents papers stored for many years without any precautions. IN some year due to chemical reaction, the quality of the paper get degraded which affects on the printed or handwritten information. The documents which are mostly affected are the important document like historical documents, some government data, property papers, ancient documents having scientific and cultural importance etc. the most of the degraded documents are unuseful because it is affected by strains, intensities variation, improper illumination, smear, ink seepage. The degraded image Binarization is a crucial task as the noise pattern is not of the particular pattern. It is varied document by document. Hence,t he main aim of the degraded image Binarization techniques is to remove the information other than text and preserve the text strokes of the extracted texts. In general most of the approaches use global or local thresholding methods for image Binarization. In the case of local Binarization method, it is proven that it provides good results than global thresholding when it combined with new improved algorithms. In global thresholding, the single threshold value is calculated from the image intensity variations and applied over the image. That may misclassify the foreground and background when the variation is large.

Binarization is the process of segment out the foreground object from the background pixels. In the case of degraded document Binarization, it is defined as the segmentation of the tests part from the background non-text noise.

The research on the degraded document Binarization was started thirty years ago. The number of algorithms has been developed but still, it is unsolved problem.

The proposed paper is organized is as follow: Number of papers has been reviewed and some of them discussed in section II. IN section III, the proposed improved Image Binarization approach has been discussed in detailed. The Results are presented in the qualitative and quantitative way is section IV. Finally, in section V the proposed system has been concluded.

II. LITERATURE SURVEY

Numbers of approaches has been developed by researchers for image Binarization. Some of them are reviewed in this section.

A. Otsu's Method

It is the most popular method for Binarization of the image. It is most efficient global thresholding method. This method is developed by Nobuyuki Otsu. In this method the clusters are made and separate it into two clusters of Gaussian distributions [1]. It automatically calculates the single global threshold value which is applied to the each pixel of an image

for converting the grayscale image into the binary image. The algorithm is developed for separation of foreground and background with minimum interclass variance. This method is good when an interclass element has minimum pixel difference. It is the simple and effective method but it takes too much time to be practical for multilevel threshold selection.

B. Niblack's Method

Niblack is the Adaptive local thresholding method. The threshold is decided at the pixel level. It depends on the variance, range surface-fitting parameters of the neighborhood pixel [2]. The moving rectangular mask of different size calculates the threshold. It is obtained by local mean m (i, j) and standard deviation σ (i, j) of the window. The threshold T is given by:

$$T(i,j) = m(i,j) + k.\sigma(i,j) \quad (1)$$

Where, k is constant and its value is lies between 0 - 1.

Niblack's method is adaptive threshold method. But the disadvantage is text stokes contain some noisy pixel. To remove this non stroke edges post processing algorithms needs to be developed.

C. Sauvola Method

It is improved version of Niblack method.[3] It is the local thresholding method based on the local-variance of an image. The threshold value is decided by the estimation of local mean and local standard deviation. Mathematically, it is given by-

$$T(i,j) = m(i,j) * \left[1 + K\left(\frac{\sigma(i,j)}{R} - 1\right)\right] \quad (2)$$

Here, m and σ are again the mean and standard deviation of the whole window, and k is a fixed value. An optimal combination of k and the sliding window will produce a good binary image. The sauvola method performs better on degraded document images but is computationally slow and sensitive to the selection of window size and free parameter values.

D. Bernsen Method

The local adaptive method proposed by Bernsen [4] is based on the contrast of an image. It calculates the mean of the difference of the local minimum and local maximum of the window and middle value of this difference is considered as a threshold value. However, if the contrast is below a certain contrast threshold k,

$$C(i,j) = I_{high}(i,j) - I_{low}(i,j) \quad (3)$$

Where C(i, j)jdenotes the contrast of an image pixel (i, j). I_{high}(i, j)and I_{low}(i, j) denote the maximum and minimum intensities within a local neighborhood window of (i, j) respectively.

This method is simple. But the limitation of this method is that it does not work properly on degraded document images with a complex background.

E. LMM method

This method is an improvement over Bernsen's method [5] and handles the documents with a complex background well. In this method, the local image contrast introduces a normalization factor. This normalization factor compensates for the image variation within the document background. Here the local image contrast is evaluated as follows:-

$$C(i,j) = \frac{I_{max}(i,j) - I_{min}(i,j)}{I_{max}(i,j) + I_{min}(i,j) + \varepsilon} \quad (4)$$

Where, ε is a positive but infinitely small number that is added in case the local maximum is equal to 0.[5] In particular, the numerator (i.e. the difference between the local maximum and the local minimum) captures the local image difference that is similar to the traditional image gradient. The denominator acts as a normalization factor that lowers the effect of the image contrast and brightness variation.

From the previous work, it has been observed that, most of the developed algorithms depend on statistical methods and do not consider the nature of document images. So there is need to develop such cumulative approach for the algorithm which restores the degraded document with high accuracy and will provide better automation.

III. PROPOSED METHOD

Binarization is an essential step for document image analysis. The degraded document image is affected by different noises and variable contrast. Hence there are chances of misclassification between the non stroked and text stroke pixel. So, there is a need for adaptive binarization technique for degradation of document images.

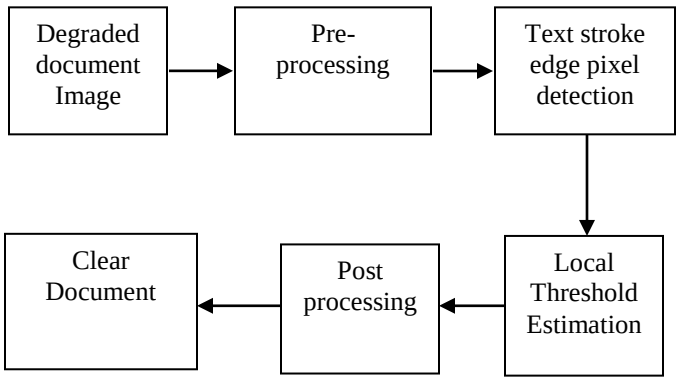


Fig -1: Block diagram of the proposed system.

A. Degraded Document Image

The input of the proposed algorithm is degraded document image. The degraded document is digitalized by the scanner and it is input to the system. In this system, images from Document Image Binarization Contest (DIBCO) database is

used for evaluation [6]. The DIBCO database provides the variety of degraded document and invites researchers to developed algorithms for Binarization.

B. Preprocessing

The input degraded document image from DIBCO database is feed to the proposed system. The degraded documents are affected by the noise. The noisy images first preprocessed by the median filter of kernel size 3x3. Further, the contrast of the image is improved by using histogram equalization. The histogram equalization enhances the contrast of images by adjusting the brightness of pixel values.

C. Contrast Image construction

This section has two main steps: Calculation of local image contrast and local image gradient. Local image contrast is referred as the difference between minimum and maximum values within the mask while local image gradient is the directional changes in the intensity values.

In this method, we used LMM method to calculate local image contrast and local image gradient. In LMM method, the difference between the local minimum and local maximum suppress the image variation but it is failed to extract the white text properly so to get accurate text regions, the combination of image contrast and image gradient is used and it gave by:

$$C_a(i,j) = \alpha C(i,j) + (1-\alpha)\big(I_{max}(i,j) - I_{min}(i,j)\big) \quad (5)$$

Where,,C (i,j) gives local image contrast of document image. To get higher value of the contrast, the tuning parameter α in introduced into the equation and it is calculated by

$$\propto = \left(\frac{std}{128}\right)^{\gamma} \quad (6)$$

Where, γ enhance the contrast of the image. The value of gamma decided the accuracy of the system.

D. Text stroke edge pixel detection

The edge is the difference between the brightness values within the image. In the proposed approach, Otsu Binarization is applied first to find out the local high nad local low-intensity pixels in a window. This is helpful to evaluate the contrast map. Then, the canny edge detection method is applied to get fine edges of the text. Canny edge detection method has an advantage that it reduces the chances of false positive and false negative edges.

E. Local Threshold Estimation

The higher contrast edges are extracted by the canny edge detection method. The observed text stroke edges and background has observable distance so it is easy to separate out the edge pixels from the background. In the local threshold estimation, consider the edge pixels, The local threshold is estimated by considering the edge map, if edge pixel is 0 and next adjacent pixel is 1 then it is considered as an edge else discard that pixel. The local threshold is estimated by using equation

$$R(x,y) = 1 \quad Edg > Emean + Estd$$
$$= 0 \quad Otherwise \quad (7)$$

In the remaining edge pixel, find out the adjacent detected edge pixels which are like the both sides of the text. After that calculate the distance between the two adjacent detected pixels which helps in finding the stroke edge width by using most frequently occurring adjacent edge pixel.

F. Post Processing

Post processing is the process of preserving true edge stoked pixel and discard others. After that the pixels are checked whether the pixels are within the for ground or background using 4- connected and 8-connected techniques.

Another approach is introduced in the post processing is the toggle filter [7]. It is the combination of erosion and dilation. If the text strokes are over dilated then text strokes have to be eroded and vice versa. The algorithm for the toggle filter is explained below.

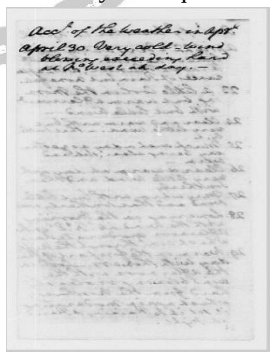
$$f_{toggle}(i,j) = \begin{cases} (f \ominus B)(i,j) & if\ (f \ominus B)(i,j) - f(i,j) > f(i,j) - (f \ominus B)(i,j) \\ (f \oplus B)(i,j) & if\ (f \oplus B)(i,j) - f(i,j) < f(i,j) - (f \ominus B)(i,j) \\ f(i,j) & Otherwise \end{cases} \quad (8)$$

IV. Result Analysis

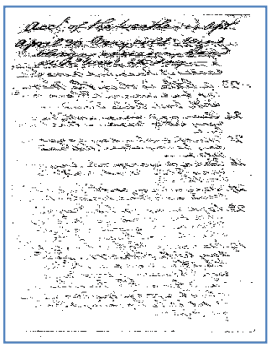
The results of the proposed system are evaluated on the DIBCO database. The results are presented in both qualitative and quantitative analysis.

A. Qualitative analysis

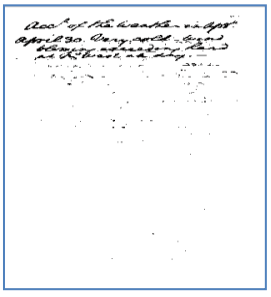
The analysis in qualitative analysis is presented below



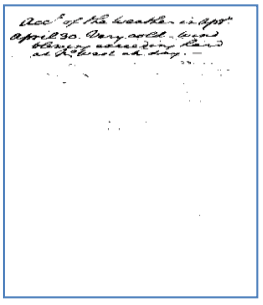
(a)



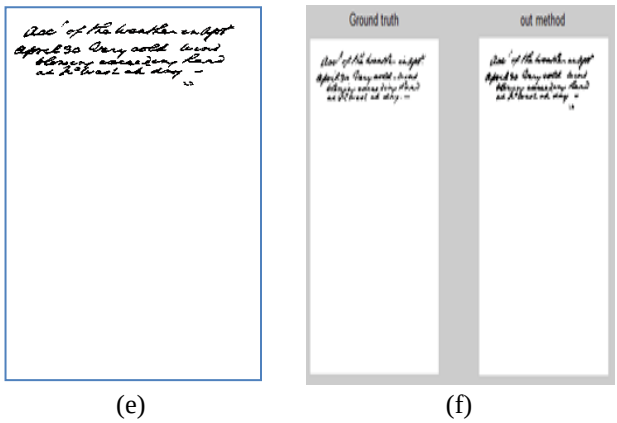
(b)



(c)



(d)



(e) (f)

Fig -3: Qualitative analysis (a) Input degraded document color image from DIBCO 2009 dataset (b) Bernsen contrast Image (c)output of LMM method (d) output of Contrast image construction (e) Output of Toggle filter (f)Ground truth and output of proposed system for γ = 1.

B. Quantitative analysis

The proposed system can be represented in terms of accuracy and f measures. The accuracy of the system in terms of performance measures is given by

$$Accuracy = \frac{(TP+TN)}{(TP+TN+FP+FN)} \quad (9)$$

$$fmeasure = \frac{(2*(precision*recall))}{(precision+recall)} \quad (10)$$

$$precision = TP/((TP+FP)) \quad (10)$$

$$recall = TP/((TP+FN)) \quad (11)$$

Table -1: Qualitative analysis

Sr. No	Methods	Accuracy	F_Measure
1	Otsu	98.35%	98.65%
2	Bernsen	93.78%	96.73%
3	LMM	98.42%	98.47%
4	Proposed	99.02%	99.50%

The comparative analysis of different degraded image Binarization technique has been presented graphically in Chart 1.

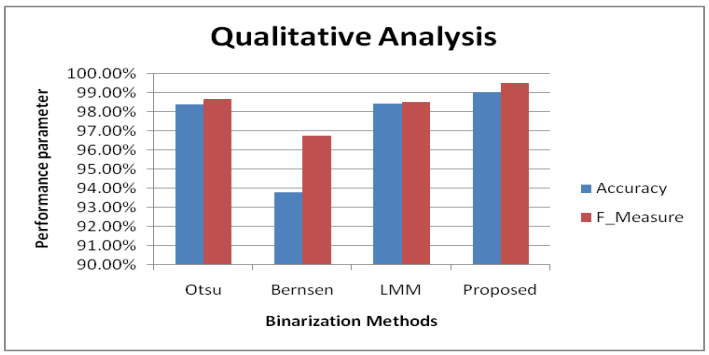


Chart -1: comparative analysis of degraded image Binarization Techniques

V. CONCLUSION

The degraded document Binarization is an active research area in the field of image processing and computer vision and pattern recognition. The degraded document image having variation in their contrast and every image has different nature. Hence it is difficult to Binarization with good accuracy. In the proposed approach, we provide the solution for Binarization of the degraded document of different noise and illumination by inserting gamma parameter. The proposed approach achieves the 99.02% accuracy and 99.50% f-measure value on DIBCO 2009 database.

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