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An Approach to Enhance and Binarize the Degraded Document Images by the Method of Thresholding

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Abstract:
Document image binarization is usually performed in the preprocessing stage of different document image processing related applications such as optical character recognition (OCR) and document image retrieval. It converts a gray-scale document image into a binary document image and accordingly facilitates the ensuing tasks such as document skew estimation and document layout analysis. As more and more text documents are scanned, fast and accurate document image binarization is becoming increasingly important. Though document image binarization has been studied for many years, the thresholding of degraded document images is still an unsolved problem. This can be explained by the fact that the modeling of the document foreground/background is very difficult due to various types of document degradation such as uneven illumination, image contrast variation, bleeding-through and smear. In this paper, the preprocessing step has been done with algorithm, which preprocesses the degraded document images. The binarization of the document is followed by local thresholding and Peter Kovesi algorithms. The post processing of the binarized document images involves de-speckling and sharpening of the enhanced images.

Keywords: Binarization, Thresholding, Degraded Documents.

1. INTRODUCTION

As the approach drives towards enhancing the degraded document images, the works of various other authors had been reviewed for the betterment of our work. Stubberud et al. [1] trained an adaptive restoration filter and applied the filter to the distorted text image that the OCR system could not recognize. Adrian et al. [2] proposed the linking broken character borders with variable sized masks to improve recognition accuracy. Banerjee et al. [3] proposed the contextual restoration which learns the text model from the degraded document itself. Touching and broken characters were corrected by the algorithm. Lazzara et al. [4] recently improved Sauvola's method using a multiscale scheme. Biswas, B et al [5] "A Global-to-Local Approach to Binarization of Degraded Document Images" This article manages binarization of degraded document pictures. In the proposed methodology, canny edge picture of the data corrupted record picture is gotten in the wake of smearing it with a Gaussian channel. Ntirogiannis et al. [6] proposed a pixel-based binarization evaluation methodology for historical handwritten/machine-printed document images. Bal [7] proposed a language-independent semi-automated system for enhancing degraded document images that is capable of exploiting inter and intra-document coherence. Likforman-Sulem et al. [8] compared two image restoration approaches for the pre-processing of printed documents. Chen et al. [9] introduced Non-local means method and used to remove noises along with adaptive thresholding. Binarization of a grey scale document picture by Chi, Z et al [10] is a standout amongst the most essential ventures for programmed report preparing. The paper displays a two-stage archive picture binarization approach. The methodology applies a district based binarization system first to the entire picture and uses a neural system based binarization procedure to those content squares in which a decent character division can't be attained to at the first stage. Singh et al. [11] proposed a method for severely degraded and non-uniformly illuminated documents. The strokes of the characters based on a combination of a simple feature point detection scheme and a novel stroke segment connecting method was proposed by Lin et al.[12] and progressed it. Liu et al. [13] proposed the adaptive window anisotropic diffusion for speckle reduction. Wellner [14] proposed a method where he first treat the image as a single row of pixel composed of all the rows in the image lined up next to each other.

2. PROPOSED WORK

We proposed a technique of modified adaptive thresholding that presents the binarization and enhancement of the degraded and broken document images. The usual noises that arise due to many factors like insufficient light, illumination, dust, environmental effects, colour patterns and much more can be cleared away in the pre-processing stage with the Weiner filter. The pre-processed image thus gives a noise-removed version of the degraded document image. The pre-processed images are further used in the thresholding process. The thresholding technique used here is the modified adaptive thresholding, which focuses on local regions of the document image rather than the whole image region (Proposed Method). Thus it paves a way for segmentation of degraded document image component and the normal document image component. The implementation of adaptive thresholding differs from Pierre Wellner's original adaptive thresholding algorithm that was used in the existing work (Chen et al.,), in which the local weighted mean just along

the row, or pairs of rows, in the image using a recursive filter was calculated. Here, we use symmetrical 2D Gaussian smoothing to calculate the local mean. This also offers the option of using median filtering as a robust alternative to the mean and offers the option of using a fixed threshold relative to the mean/median. It then eliminates the degraded component through modified Wellner's adaptive thresholding method. Later, the segmented image is taken as the input for post-processing stage where the enhancement of this document image is carried out. This stage holds inner stages such as de-speckle removal and edge enhancement. The post processing step proceeds with the anisotropic diffusion technique of de-speckling the unwanted noises from the segmented image. The anisotropic diffusion involves modification of image via the partial differential equation Perona and Malik. Thus, it gives an enhanced image with less speckle noise. In the other stage of post-processing, edge enhancement is carried out using the Laplacian of Gaussian technique for the enhancement of edges in the final result. At the end of all the stages, a well enhanced and binarized image is obtained as the result of involving the required algorithms and techniques with much low processing time. The upcoming sub-sections explain in detail about the proposed work with respect to each step of the binarization and enhancement techniques involved.

2.1 PRE-PROCESSING:

Noise Removal Using Weiner Algorithm:

Weiner filter is optimal in terms of the mean square error. It minimizes the overall mean square error in the process of inverse filtering and noise smoothening. The Weiner filter is a linear estimation of the original image. The Wiener2 filter tailors itself to the local image variance. Where the variance is large, Wiener2 performs little smoothing. Where the variance is small, Wiener2 performs more smoothing. Wiener2 estimates the local mean and variance around each pixel.Mean (μ) around each pixel is calculated as:

$$\mu = \frac{1}{NM} \sum_{n1,n2,\in\eta} a(n1,n2) \quad \text{------(1)}$$

Also, Variance (σ) around each pixel is calculated as:

$$\sigma = \frac{1}{NM} \sum_{n_1,n_2,\in\eta} a^2(n_1,n_2) - \mu^2 \text{-----(2)}$$

where η is the N-by-M local neighborhood of each pixel in the image A and n1, n2 are the pixels that belong to η. wiener2 then creates a pixelwise Wiener filter using these estimates,

$$b(n_1,n_2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2} (a(n_1,n_2) - \mu) \text{----(3)}$$

2.2 THRESHOLDING:

Modified Adaptive Thresholding (Proposed Technique):

Thresholding is used to segment an image by setting all pixels whose intensity values are above a threshold to a foreground value and all the remaining pixels to a background value. Whereas the conventional thresholding operator uses a global threshold for all pixels, adaptive thresholding changes the threshold dynamically over the image. This more sophisticated version of thresholding can accommodate changing lighting conditions in the image, e.g. those occurring as a result of a strong illumination gradient or shadows.

$$f_s(n) = \sum_{i=0}^{s-1} P_{n-i} \quad \text{-----(4)}$$

Pierre Wellner's equations on adaptive thresholding are as follows. The Sum and Average of the values of 's' pixels are computed using equation (4)

$$T(n) = 1 \text{ if } Pn < (f_s(n) / s)(100\text{-}t/100)$$

$$T(n) = 0 \text{ Otherwise} \quad \text{-------(5)}$$

The resulting thresholded image T(n) will be either 0 or 1. That is, 1 will be assigned for black and 0 for white. It depends on't' percent darker than average value.The implementation differs from Pierre Wellner's original adaptive thresholding algorithm as it calculated the local weighted mean just along the row, or pairs of rows, in the image using a recursive filter. Like global thresholding, the concept of adaptive thresholding is used to separate desirable foreground image objects from the background based on the difference in pixel intensities of each region. Global thresholding uses a fixed threshold for all pixels in the image. Local adaptive thresholding, on the other hand, selects an individual threshold for each pixel based on the range of intensity values in its local neighborhood. Adaptive method, thresholds an image using a threshold value that is varied across the image. It works quite well ontext with shadows.

2.3 POST PROCESSING:

(a). De-speckle through Anisotropic Diffusion:

Anisotropic diffusion algorithms remove noise from an image by modifying the image via a partial differential equation. Perona and Malik replaced the classical isotropic diffusion equation.

(b). Edge enhancement through Laplacian of Gaussian :

It is common for a single image to contain edges having widely different sharpness and scales, from blurry and gradually to crisp and abrupt. Edge scale information is often useful as an aid towards image understanding. For instances, edges at low resolution tend to indicate gross shapes, whereas textures tends to become important at higher resolution.

3. PROPOSED WORK

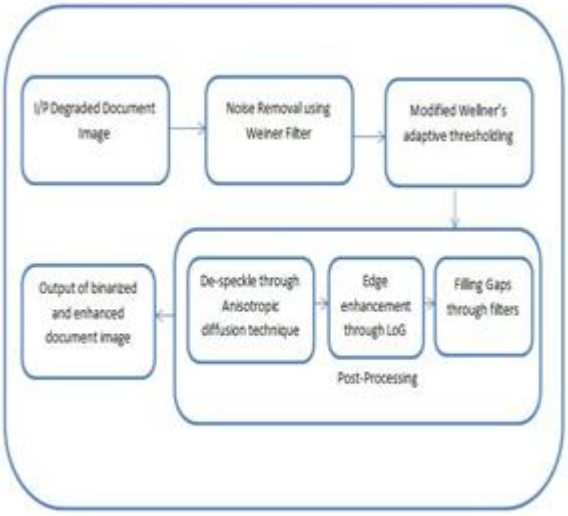

Figure.1. Block Diagram of Proposed Work

3. PROPOSED SYSTEM ALGORITHM

The following are the steps involved in the binarization and enhancement of degraded document images through the method of thresholding.

STEP 1: Degraded and a broken document image is taken as initial input for the system to process.

STEP 2: The image that was taken as an input is made to undergo the conversion of RBG to Grey Scale component, to make the image appear easier for processing.

STEP 3: The converted grey scale image with the noise in it is taken for pre-processing stage, where the noise removal Weiner algorithm is applied.

STEP 4: Once the noise from the grey scale image is removed, the adaptive thresholding technique of Wellner is implemented to segment the foreground and background components of the image.

STEP5: Thethresholded image is then taken for post-processing stage

4. EXPERIMENTAL RESULTS

In our paper work, the source of document images were collected from datasets of DIBCO and other online sources set of handwritten documents, old papers and degraded document images. Those images vary in the type of different noise level and illumination effects. The proposed approaches and algorithms were implemented in MATLAB software and the results have shown a vast improvement and accuracy. The comparison between the processing time of existing work of Chen et al.,[9] and our work has been shown in the Table 1 and the comparison between the Precision and recall of existing work and our work are compared. It is then seen that, our modified adaptive thresholding takes less processing time and high precision, recall than other methods.

Table.1. Processing Time of different algorithms evaluated on DIBCO dataset

Methods	Processing Time(s)
Gatos et.al	2.02
Chou et.al	1.90
Chen et.al	1.56
Modified adaptive threshold	1.45

Table.2. Performances of different algorithms evaluated on DIBCO dataset

Methods	Precision	Recall	F-measure
Gatos et.al	0.90	0.91	90.5
Chou et.al	0.92	0.91	92.8
Chen et.al	0.97	0.95	95.7
Modified adaptive threshold	0.98	0.97	97.4

In figure 2 and figure 3, the graphical representation of the Performances of various different methods and their processing timesthat were performed for the binarization of various degraded and broken document images are given. It clearly shows that, the modified adaptive thresholding method takes much better performance in terms of higher precision and recall when compared to other methods with less processing time

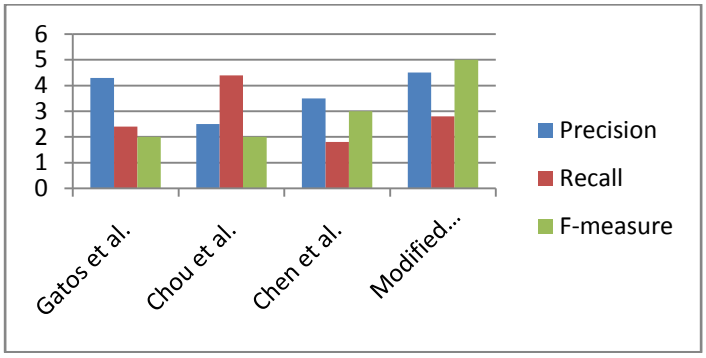

Figure.2. Processing Time of different methods on DIBCO Dataset

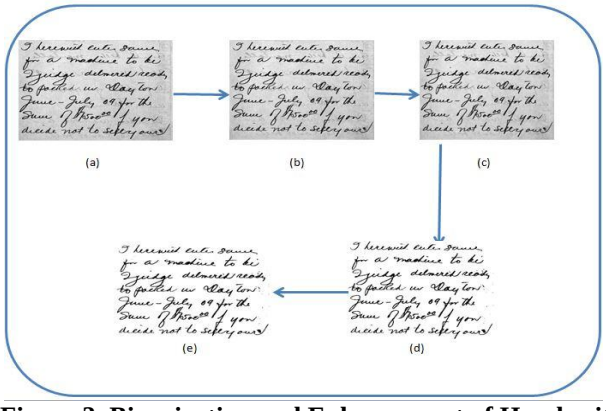

Figure.3. Binarization and Enhancement of Handwritten

Degraded Document Image

(a) Original Degraded Image (b) Grey Image Conversion (c) Pre-Processed Image using Weiner Filter (d) Binarization of image using Wellner's modified Adaptive Thresholding (e) Post-Processed Image using de-speckling techniques. In this Paper, the degraded document images collected from DIBCO dataset of various years, containing about 163 images and other set of images about 90 images are used. Those images varied from each other in terms of illumination, shadows, ink spilling, broken images, degraded with water, dusted images, images that exist with longer time span. The proposed method shows considerable performance on the images that were collected for the experimental purpose.

5. CONCLUSION AND FUTUREWORK

We framed a new approach for degraded document image binarization. The pre-processing step has been done using the Weiner filtering method. Later, the pre-processed image has been made to undergo the modified form of Wellner's adaptive thresholding. To get the best result out, the post processing step of de-speckling through anisotropic diffusion method, edge enhancement through laplacian of Gaussian method has been carried out. The current method, moves around the modified adaptive thresholding of Wellner. This can be improvised to reduce the cost of computation in future. Also, the speckle noise can be reduced even more with other speckle reducing techniques.

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7. ACKNOWLEDGEMENT

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