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Degraded Document Image Enhancing in Spatial Domain using Adaptive Thresholding and Contrasting

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Abstract: ***In this paper we enhance the readability and comprehensibility of degraded documents using adaptive contrasting and thresholding in spatial domain. Segmentation of foreground text from the background of degraded document images is a very difficult task due to the large variations between the background and the foreground of degraded document images. This paper addresses these issues by using adaptive image contrast and by making use of the image contrast that is defined by the local image maximum and minimum has been implemented. The adaptive or local image contrast is an amalgam of the local contrast and the local gradient of the image whose text and background variation caused by different types of document degradations. When we compare this with the gradient of image, the contrast of image calculated by the local maximum and minimum has very good property that it is more tolerant to the uneven illumination and other types of document degradation such as smear.***
Keywords: Contrast Image, Degraded document, Gradient image, Historical image, Image enhancement.

I. INTRODUCTION

Degraded documents are the documents obtained from various situations. Degraded document examples include historical document depositories, document obtained in legal security investigations, medical archives and old manuscripts. Degraded documents are difficult to read and are hard to analyze them using computerized techniques. Document image can be divided into two classes, namely, the foreground text and the document background[2].

The document image binarization has been studied for many years but the thresholding of degraded documents is still an unsolved problem due to the

large inter/intra- difference between the foreground text and the background of document across different document images. The handwritten text

within the degraded document images usually show a certain amount of variation in terms of the stroke width, stroke brightness, stroke connection, and document background.[3] In addition, historical documents are often degraded by the ink bleeding, fading and addition of dust particles.

The important problem in image processing is restoration. The goal of the restoration approach is to improve the image readability. Removal of degradation is important as image analysis and acquisition system has more application in society [4].

Fig.1 Example of historical document image that suffer from various types of document degradation.

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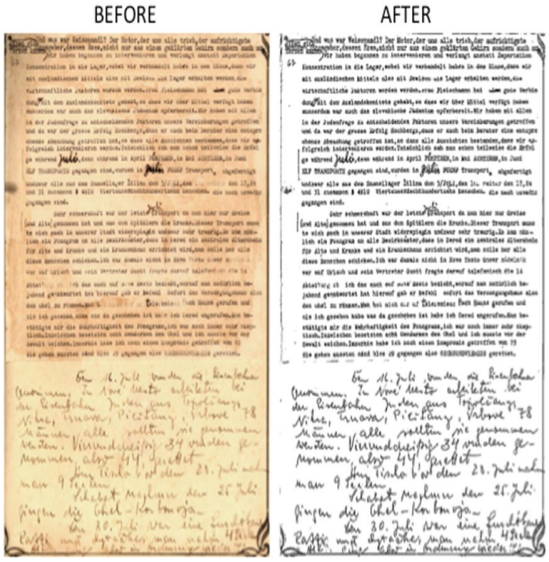

Fig.2 This image shows the degraded document which has been readable by applying contrasting and thresholding**.**

Restoration is a technique used to reconstruct or recover an image that has been degraded by some degradation phenomenon. There are many reasons that could cause degradation of an image, and image restoration is one of the major thing in today's Digital Image Processing due to its wide area of applications. Because of the imperfection of the physical imaging system and due to various physical limitations on every application a recorded image will always be a degraded version of an original image.

There exists a large number of possible degradations that an image can suffer. General degradations are blurring, motion and noise. Blurring is caused when an object in the image is outside the cameras depth of field during the exposure. Motion blur is caused when the object moves relative to camera during an exposure.[4]

Photographic defocusing is also a kind of problem in many different images. This type of blurring is caused due to effects at the camera aperture, which spreads a point of incoming light across a circle of confusion. Noise is generally a distortion caused due to the imaging system instead of the scene recorded. Noise results in random variations to pixels in the image.[2]

Methods of Enhancing the image are basically two types

1) *Spatial Domain Methods* (Image Plane): Techniques are based on direct manipulation of pixels in an image.
2) *Frequency Domain Methods:* Techniques are based on modifying the Fourier transform of the image.

II. FUNCTIONAL BLOCK

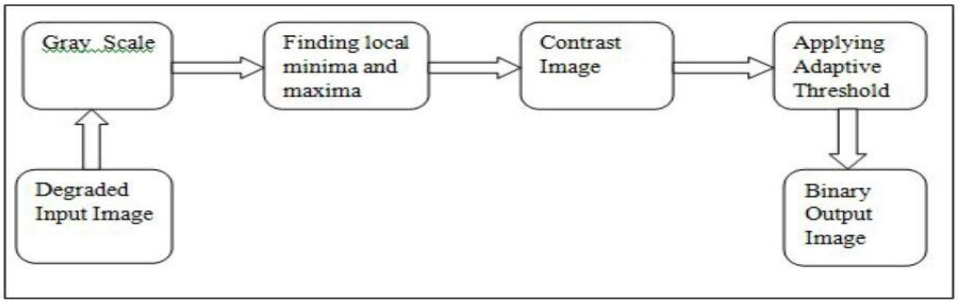

Fig.3 Degraded document image enhancing process

The figure 3 illustrates how the degraded document image is made readable by applying two steps i.e contrasting and thresholding. The degraded image has lot of noise and dust particles. Firstly we take a degraded document and convert it into a gray scale image. This gray scale image consists of 0-256 shades of gray. Then the gray image is converted to contrast image by applying local maxima and minima [3].In order to make the text much clear and remove noise we perform one more step that is thresholding. Finally we obtain a noise free image which is a binary image and has only two levels 0 or 1.

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III. PROPOSED METHOD

This section describes the proposed ancient document image thresholding technique. In this generally we divide this section into three subsections, which deal with the contrast image construction, the high contrast pixel detection, and the local threshold estimation respectively.

It can be categorized into three steps

1) The contrast image construction
2) The high contrast pixel detection
3) The local threshold estimation

A. Contrast Image Construction

The image gradient is widely used for edge
detection. The image gradient of document is obtained by absolute image difference within a local neighbourhood window which do not incorporate the image intensity itself and is very sensitive to the image contrast/brightness variation. It is used to detect the text stroke edges of the document images effectively that have a uniform document background.

On the other hand, it usually detects most of the non-stroke edges from the background of degraded document that often contains certain image variations due to noise, uneven lighting, bleed-through, etc. To extract only the stroke edges correctly, the image gradient needs to be normalized to compensate the image variation within the document background.

Take a historical document image which is unevenly illuminated as an example, the gradient of an image pixel (around the text stroke boundary) within bright document regions may be much higher than that within dark document regions. To detect the high contrast image pixels around the text stroke boundary properly, the image gradient needs to be normalized to compensate for the effect of the image contrast/brightness variation. At the same time, the normalization suppresses the variation within the document background as well. In this proposed method, we suppress the background variation by using an image contrast and highlight the text. The image contrast is calculated based on the local maximum and minimum of a particular pixel of an image as follows:

$$D(x, y) = \frac{f_{max}(x, y) - f_{min}(x, y)}{f_{max}(x, y) + f_{min}(x, y) + \varepsilon}$$

where $f_{max}(x, y)$ and $f_{min}(x, y)$ are the maximum and the minimum image intensities within a local neighbourhood window. In the implemented system, the local neighbourhood window is a 3×3 square window. The term ε is a positive and infinitely small number, which is added if the local maximum is equal to 0. The image contrast in above Equation lowers the image background and brightness variation properly. In general, the numerator (which is the difference between the local max and the local min) takes the local image difference which resembles the general image gradient. The denominator acts as a normalization factor which lowers effect of the image contrast and brightness of the image. For image pixels which are in bright regions near the text stroke boundary, the denominator is large, which is used for neutralization the large numerator and accordingly results in a relatively low image contrast. The image pixels within dark regions around the text stroke boundary make the denominator quite small, which compensates the small numerator which results in a relatively high image contrast. As a result, the contrast of the image pixels (lying around the text stroke boundary) within both bright and dark document regions converge close to each other and all the values lie in between 0-1 and this facilitates the detection of high contrast image pixels lying around the text stroke boundary.

At the same time, the image contrast suppresses the variation that are present in the document background properly. For document background pixels, the local minimum is usually much brighter when compared to the image pixels lying around the text stroke boundary. As a result, the contrast of the background will be suppressed due to the high denominator.

Similarly the image pixels with identical image gradient lying around the text stroke boundary in dark regions will have a much higher image contrast. This enhances the difference between the image pixels around the text stroke boundary and those within the background region with high variation because of the document degradation.

B. High Contrast Pixel Detection

The main reason of construction of the contrast image is to detect the desired high contrast image pixels lying around the text stroke boundary. The constructed contrast image has a clear bimodal pattern where the image contrast around the text stroke boundary varies within a less range but is obviously much larger compared to the image contrast within the document background. We therefore recognize the required high contrast image pixels (lying around the text stroke boundary) by using Otsu's global thresholding method.

Most of the high contrast image pixels detected through the binarization technique of the contrast image corresponds to the desired image pixels around the text stroke boundary. On the other hand, the gradient image binarisation introduces a certain amount of undesired pixels that generally lie within the degraded document background.

C. Historical Document Thresholding

The text pixels in the foreground of an image can be differentiated from the document background pixels once the high contrast image pixels around the text stroke boundary are recognized correctly.

The thresholding of document from the detected high contrast image pixels is based on two observations:

1) The text pixels should be near to the detected high contrast image pixels because most of the recognized high contrast image pixels lie around the text stroke boundary.

2) The intensity of most text pixels should be close or lower than the average intensity of the detected high contrast image pixels within a local neighbourhood window.

For each of the degraded document image pixel, the number of the detected high contrast pixels are determined within the local neighbourhood window. The degraded document image pixel is considered as a text pixel if the number of high contrast image pixels within that particular neighbourhood window are larger than the threshold value. The document image pixel is classified based on its intensity of image relative to that of its neighbouring high contrast image pixels as follows:

$$R(x,y) = \begin{cases} 1 & N_e \geq N_{min} \quad \&\& \\ & I(x,y) \leq E_{mean} + E_{std}/2 \\ 0 & \text{otherwise} \end{cases}$$

Emean and Estd are the mean and the standard deviation of the image intensity of the detected high contrast image pixels within the neighborhood window that can be evaluated as follows:

$$E_{mean} = \frac{\sum_{neighbor} I(x,y) * (1 - E(x,y))}{N_e}$$

$$E_{std} = \sqrt{\frac{\sum_{neighbor} ((I(x,y) - E_{mean}) * (1 - E(x,y)))^2}{2}}$$

Where

I = input document image

(x, y) = position of document image pixel

E = binary high contrast pixel image

E(x, y) = 0 if the document image pixel is detected as a high contrast pixel. Ne refers to the number of high contrast image pixels that lie within the local neighbourhood window. So if Ne is larger than Nmin and I(i, j)is smaller than Emean + Estd/2, R(i, j) is set at 1. Otherwise,R(i, j) is set at 0.

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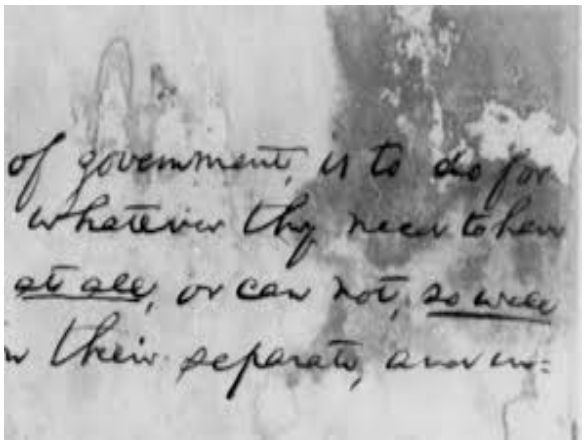
IV. EXPERIMENTAL RESULTS

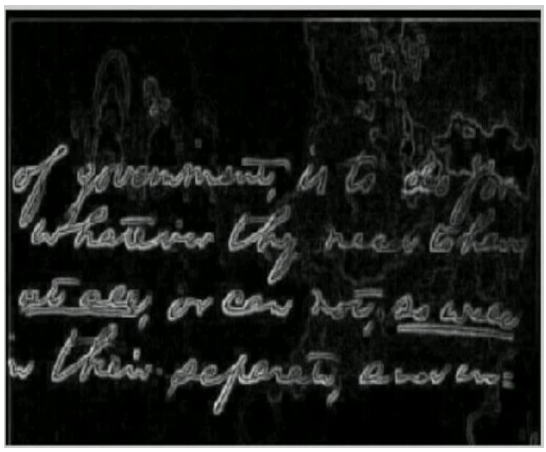
The proposed method has been tested over different handwritten images of the dataset that is used in the degraded document Image binarization technique. The degradation was produced by the combination of many degradation processes designed after degradations observed in actual documents.The dataset is composed of a number of representative document images that suffer from various types of document degradation.

These processes include local brightness degradation, blurring degradation, noise degradation and texture blending degradation.

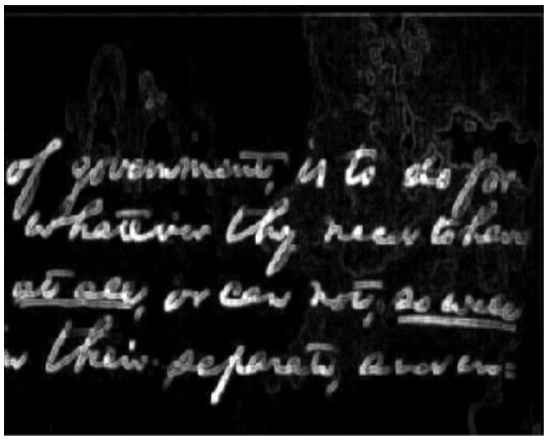
A. Input Image



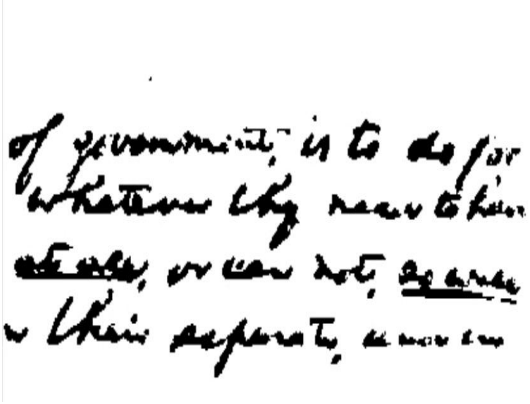
B. Gradient Image



C. Contrast Image Obtained by local Maxima & Minima



D. Result of Degraded Document using Proposed thresholding



V. CONCLUSION

This paper presents a simple but efficient ancient or historical document image binarization technique that is resistant to different kinds of document degradation such as uneven illumination and document smear. The proposed method is simple and robust, only few parameters are involved. Moreover, this method can be applied to various kinds of degraded document images. The proposed method uses the local image contrast which is evaluated based on the local maximum and minimum. Then the final step is adaptive thresholding which makes the degraded document readable and understandable.

VI. FUTURE SCOPE

The proposed method can deal with the ink bleeding, when the back-side text strokes are much weaker compared with the front-side text. But when the back-side text strokes are as dark as or even darker than the front-side text strokes, the proposed method cannot classify the two types of character strokes properly. There is a scope to work on this issue.

The proposed can be extended to deal with the degraded writings on sculptures. Generally the writings on sculptures are written long back and they suffer from different kinds of degradations. So by extending this proposed technique one can make the writings on sculptures readable.

The proposed technique can be extended further by converting the text of degraded documents into editable format which means we can change the style, font, size of the text. We can also add or delete the content of the text.

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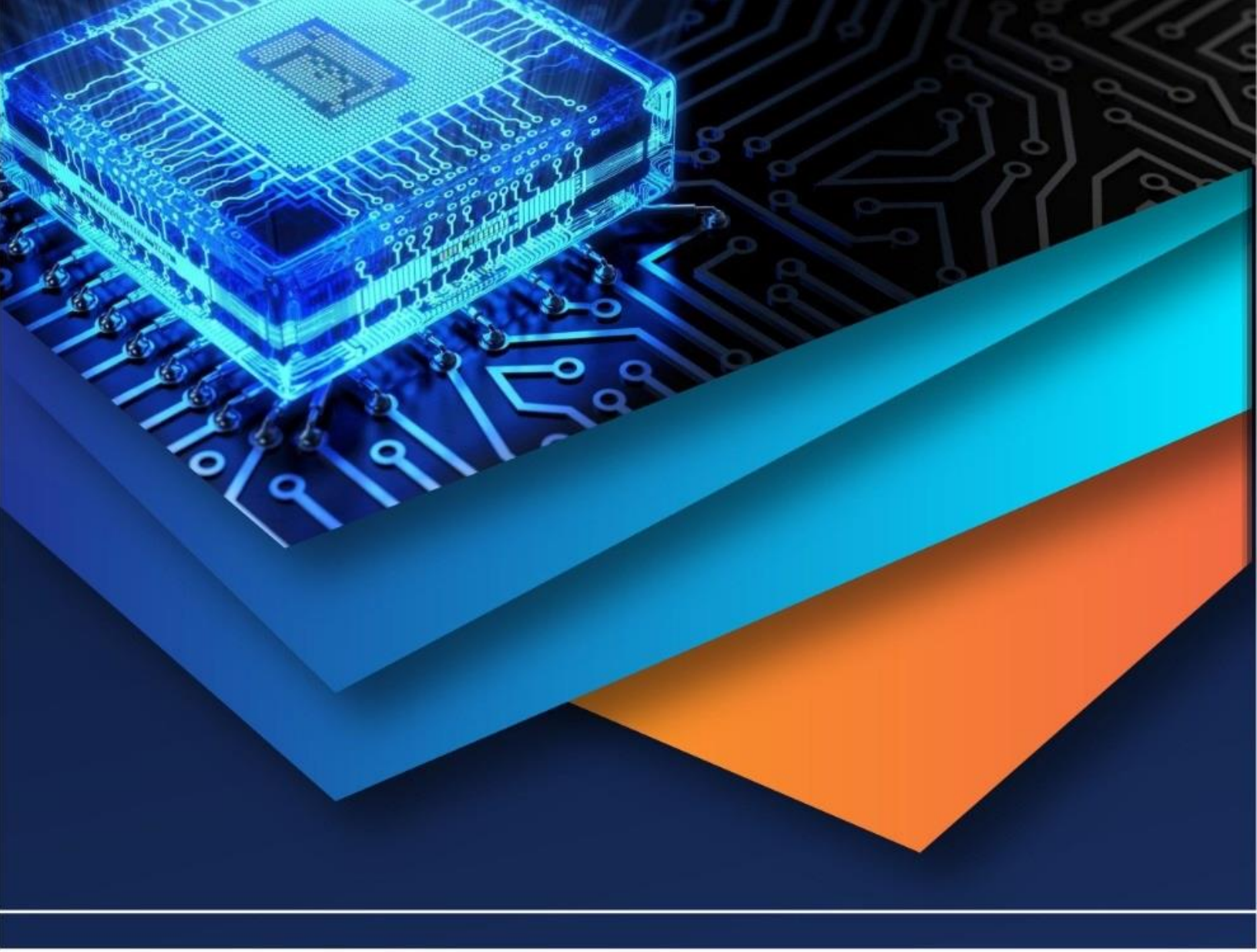

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