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A Robust Approach in Enhancing the Quality of Degraded Images and Text Restoration

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***Abstract*— The segmentation process of text identification from degraded document images is a very challenging task due to the high variation that may exist in foreground and background images of different documents. In this paper, we propose an adaptive thresholding in combination with different edge detection algorithms. The Adaptive Image Contrast of the image is enhanced to limit the variations that occur at different levels of degradation of the content present in the image. Otsu thresholding is performed on the contrast map which when combined with edge detection and total variation techniques identifies the stroke edge pixels. The output document text is segmented using local threshold values taking into account of text stroke pixels detected from the edge within a local window. In post processing morphological and logical operators are used to restore the text. The proposed method is simple and robust as it involves few parameters being tuned.**

***Index Terms*— Canny and Sobel Edge Detection, Degraded documents, OTSU Thresholding, Total Variation.**

I. INTRODUCTION

The text presented in degraded documents which is of more significance, conveys the idea of understanding vital information that happened in the past. When data is available in such documents special attention is required to extract textual information as improper handling of processing tasks may result in poor content interpretation. Documents which is of historical importance are degraded by different types of noise artifacts. Some of the well-known challenges are due to ambiguity in the clear analysis of foreground-background separation, changes due to light variations and missing information.

The proposed work enhances the quality of the text in the degraded document image using OTSU (Operational Test Support Unit) approach and adaptive thresholding is being applied to the degraded image in combination with several edge detection algorithms namely Canny, Sobel, and TV (Total Variation) techniques. The qualities of output images are evaluated by MSE (Mean Squared Error) and PSNR (Peak Signal To Noise Ratio). The best combination of threshold and edge detection techniques is selected based on the performance being evaluated.

Several techniques like optical character Optical Character Recognition (OCR) and Historical Document Retrieval have been in use widely. OCR is fast and accurate document image binarization technique which is important for the ensuing document image processing tasks such as character recognition. The proposed technique increases the contrast of the document image and hence efficient segmentation can be done which enable good restoration of text from historical documents. The gradient information depicts variation that arises in foreground and background features. Segmentation is carried based on changing thresholding values and a contrast map is built upon which Otsu approach is adopted. A bi-modal histogram differentiates foreground and background pixels present in an image. The sharp changes in brightness values are monitored to detect edges. The edge detection techniques namely Canny and Sobel are tried to bring out the information about stroke lines of text [6].

Rest of the paper is organized as follows: Section II provides details about literature survey. Section III provides details about the architecture of the proposed method for enhancement of degraded images. Section IV provides experimental results obtained after testing and Section V provides conclusion and future work that could be taken and references.

II. LITERATURE SURVEY

A. Intelligent Text Detection and Extraction from Natural Scene Image and Online Transactions

Many texts are available in a real world scene that includes traffic signs, emergency boards and so on for proper guidance to people. The captcha images in online transactions detect whether the computer machine is used by a human and illegal/misuse of information is brought down to a fair minimum. With the advancement in information retrieval, text identification and extraction from degraded images have gained much popularity. Based on the connected component labeling [2] edges of the text are detected and extracted. The interested features from the images are thus identified. Suitable noise filtering is employed. Most of the time it is prevalent to detect the presence of Gaussian noise that may occur due to improper capture of images. The differentiation of texts from non-text characters is made using certain classifiers namely AdaBoost, which provide better training to the dataset. Thus, text characters are efficiently obtained by the integration of connected component labeling and

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application of strong classifiers thereby helping in the attainment of a high precision rate that can help in reducing false positives.

B. Edge Detection Based on Self-adaptive Canny Operator

A self-adaptive canny operator detects edges of objects present in images. RGB color images were obtained and linear transformation is done. In R-B space, width of Gaussian filter is calculated. OTSU algorithm employs usage of high and low threshold values to improve automatic edge detection. Gaussian noise which may be found in image acquisition can be very well reduced. The removal of such noise is due to the fact that there exists variations in the illumination levels. Once image edges are detected using adaptive canny operator, the identification and localization of objects may be applied.

C. Thresholding

OTSU(Operational Test Support Unit) thresholding helps in choosing threshold value automatically in an image. Thresholding is a very basic operation in image processing application and Otsu thresholding is simple and effective for binarizing grayscale images. In image processing, Otsu thresholding algorithm assumes that the image is composed of two classes namely foreground and background. An optimal threshold value is computed that minimizes the weighted within class variances of these two classes. Minimizing the within class variance is equivalent to maximizing the between class variances. Otsu threshold is used in many applications from medical imaging to low-level computer vision. It has many advantages and assumptions. It is a process where each pixel in an image is converted into one bit. It is assigned the value as '0' or '1' based on the mean value of all pixels. If lesser than mean value then its '0' otherwise its '1'. It converts an image of up to 256 gray levels to a black and white image.

An easiest method is to choose an appropriate threshold value that classifies all pixels as white and black based on the value chosen. This implies that values above the threshold are considered as white and below them are treated as black. Then the problem lies in choosing the correct threshold value. Most of the cases it is difficult and even impossible. Hence adaptive image binarization is required to choose an optimal threshold value for each part of the region in an image.

$$o(i,j) = \begin{cases} 0, & g(i,j) \times S^2 < t(i,j) \\ 255, & \text{otherwise} \end{cases}$$

Adaptive thresholding compares a pixel to the average of neighboring pixels. This technique will ignore soft gradient changes and keeps hard contrast lines. It requires only a single pass and results in efficient computation depending on the scanning order of pixels. The moving average method is not suitable for representation of neighboring pixels as the samples may not be distributed evenly in all directions.

D. Land Map Images Binarization Based on Distance Transform and Adaptive Threshold

The binarization technique is mostly used for map document images. It exploits an amalgam of global and local threshold approaches best suited for binarization of document images with a complex background and overlapping objects in the foreground like maps. The Distance Transform (DT) and Adaptive threshold estimates roughly the map background and extracts the foreground information. DIBCO (Document Image Binarization Contest) [5] is a technique widely used in the evaluation of parameters related to the foreground and background separation.

E. OCR-Free Transcript Alignment

Recent advancement in digitization makes original manuscripts being available along with transcripts. The alignment of letters to coordinates in manuscript images is a challenging task. Optical Character Recognition (OCR) helps in recognition of individual letters in the manuscript image. A unique image descriptors are designed to integrate local similarities spatially. It widely uses message passing technique to match similarity. Other challenges with respect to document degradation involves variations between scripting styles and non-linear image transformations.

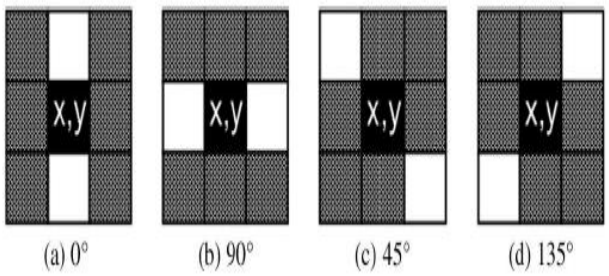
F. Extraction of Text from Compound Document Images

A robust segmentation algorithm to separate the text embedded in complex backgrounds where the text overlaps paves way for multi-thresholding. Initially the curve fitting using least square method [3] are carried out to fit the image histogram. The layers of text and background component that does not have significant variation are merged to extract text from the image.

G. Edge Detection Techniques

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect almost all types of edges in images [1]. An optimal edge detection should identify real edges in the image and noise in the image should not treated as an edge. Sobel operator has a 3x3 kernel window. Convolution masks used by Sobel operator [7] are

-1 0 1	1 2 1
-2 0 2	0 0 0
-1 0 1	-1 -2 -1



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These are used to provide information about the horizontal and vertical edges at intervals in regular patterns and helps in the detection of text in an image. Some of them are helpful in a wide range of applications where many morphological operations like are performed to provide image enhancement. Image smoothing reduces noise and also identify connected components in the image more efficiently.

III. SYSTEM ARCHITECTURE

The Fig. 1 shows the overall architecture of the system depicting the complete representation of modules.

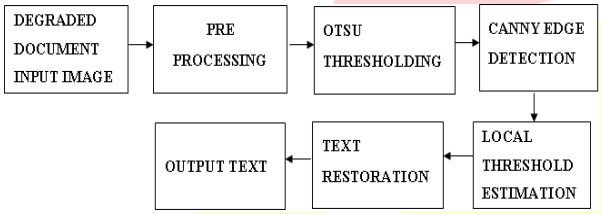

Fig. 1. System Architecture

The preprocessing step removes noise and detects non-stroke edges from the background of image that often contains variations due to noise, illumination changes and so on. The given input image is a normal text image with the plain white background. The degraded input image is sharpened by adjusting gradient changes locally. It is essential to take utmost care in performing efficient preprocessing as the refinements made to improve the quality of the image will preserve the actual data without any loss of information in further processing tasks. The contrast of the image is defined as the difference in maximum and minimum intensities within a local neighborhood window [4]. The proposed technique uses local image contrast. The contrast of the image is also enhanced by means of performing adaptive image contrast changes as follows:

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

where ϵ is a small number that is added when the local maximum is 0. This introduces a normalization to suppress the variation in the image due to poor background details.

It is then allowed to undergo OTSU thresholding which provides clear background with the text characters in the foreground being enlightened. Canny edge detection is done to restore the missing edges and histogram is viewed after the application of OTSU thresholding combined with Canny edge. When local thresholding is performed it is obvious to restore the textual information. The same process can be tried with other edge detection algorithm namely Sobel. The proposed technique is simple and robust as only a few parameters are involved and it works very well for different sets of images which are prone to vary based on different levels of degradation.

A. *Local Image Gradient*

A gradient could be any change that happens due to variation in illumination, contrast levels or degradation effects. Image gradients can be used to extract information about several descriptors of the image. It is one of the fundamental concept involved in processing a digital image that has undergone various degradations. The canny edge detector adopts image gradient for detecting edges [1] . These are helpful in the better interpretation of the image as it conveys information about the image in a more understandable and acceptable manner.

The usage of image gradient in text extraction gains a vital significance due to its ability in detecting stroke edges of the text efficiently. The main factor to consider here is about the quality of background present in the degraded document. The contrast details are normalized.

B. *Adaptive Image Contrast*

In order to overcome the problem of normalization that happens in the calculation of local image gradient adaptive image contrast is considered which combines the gradient information obtained locally and adaptive changes made in the contrast based on taking into account the intensities of neighboring pixels. An adaptive local image contrast is calculated by adding local image contrast multiplied by a factor that denotes the weight between contrast and gradient and local image gradient and is given as follows:

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

α is large when the image has significant intensity variation and is dependent on the statistical parameters calculated for image understanding. Power functions are used to model the intensity variation as follows:

$$\alpha = \left(\frac{Std}{128}\right)^{\gamma}.$$

The proposed technique captures the intensity variation efficiently and produce good results in producing textual characters as output as they are being restored by considering the black text pixels from degraded images and thereby avoiding normalization problem.

IV. EXPERIMENTS AND RESULTS

The degraded input image used in the text extraction process is a noisy image with text overwriting and confusing background imprints. The gradient and contrast images are obtained both locally and using adaptive threshold values. OTSU thresholding is performed in combination with other edge detection algorithms and Total Variation (TV) is analyzed.

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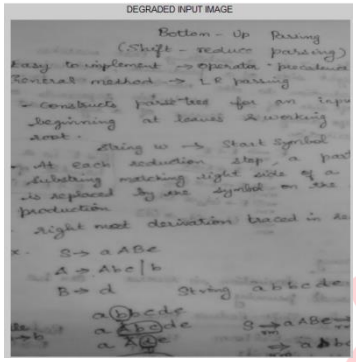

Fig. 2. Input Image

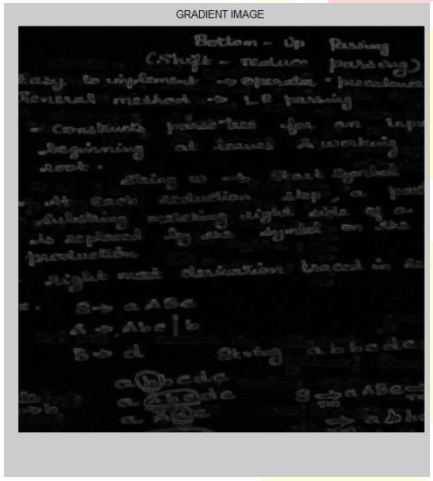

Fig. 3. Gradient Image

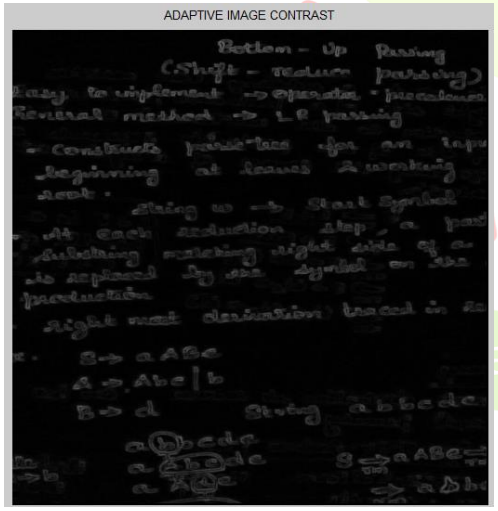

Fig. 4. Adaptive Image Contrast

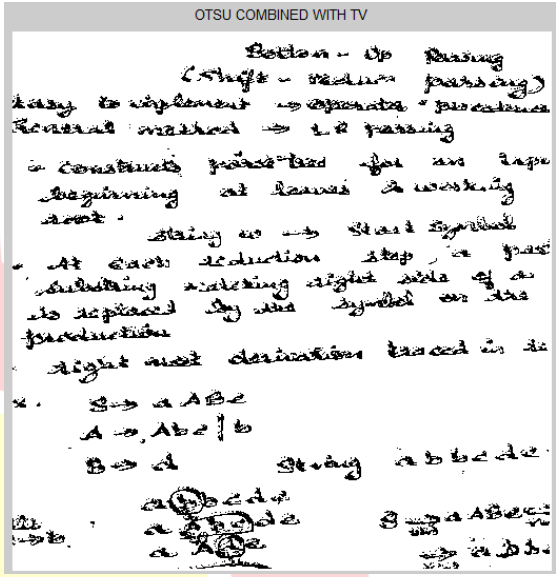

Fig. 5. OTSU Thresholding with Total Variation

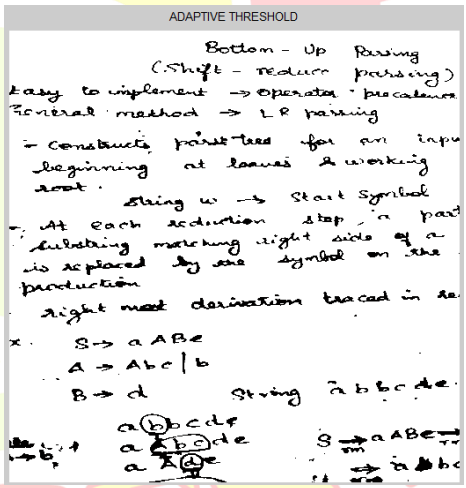

Fig. 6. Adaptive Threshold

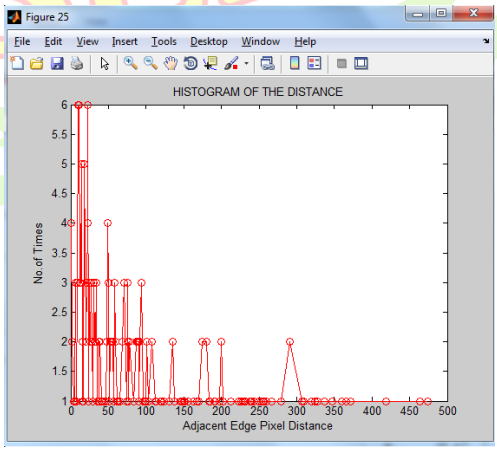

Fig. 7. Histogram Analysis

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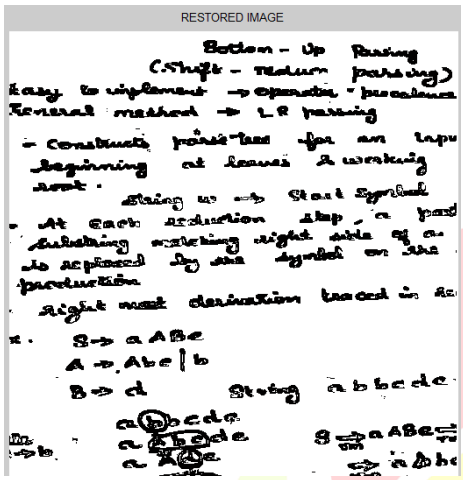

Figure 8. Restored Image

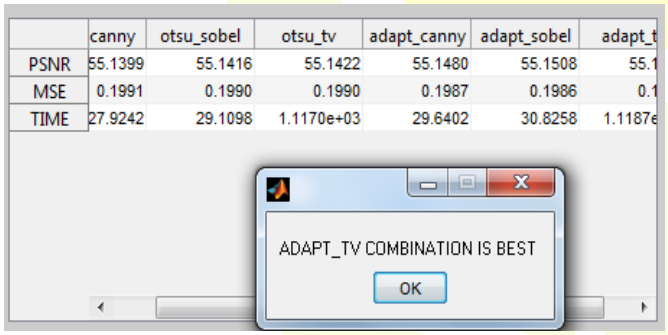

Figure 9. Performance Evaluation

V. Conclusion

This paper highlights the extraction of text from complex background using OTSU thresholding concepts combined with Canny, Sobel and Total Variation techniques based on contrast and gradient changes of intensities in degraded images. It has been tested with different types of documents having uneven illumination and tear. The results outperforms binarization methods in terms of PSNR values. The future work can involve in extraction of diagrams and tabular information other than the text content in the degraded documents.

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