Enhancement of Historical Documents by Image Processing Techniques

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***Abstract* — Historical documents are valuable source of information but commonly suffer from degradation problem. The task is to keep these documents alive to preserve the important information and the heritage of a country. The main aim of this paper is to transform them into digital form and enhance the quality and visualization of the historical images. Image processing techniques such as noise filtering, histogram equalization and power law transformation have been used to result in better representation of images. To evaluate the quality of resultant image, two performance assessment parameters; entropy and standard deviation, have been used. Matlab results indicate the efficacy of proposed technique to remove the background noise and thereby improving the quality of historical degraded images. The proposed method is much easier and may help to archive the documents in digital images with improved quality.**

***Keywords* — Historical Images; Image Enhancement; Noise Filtering; Histogram equalization; Power Law transformation method.**

I. INTRODUCTION

In image processing, one of the most tedious tasks is recognition of historical documents. Historical images suffer from several factors such as low paper quality, degradation, lack of standard alphabets, stains, noise, dense and arbitrary layout, typesetting imperfections, low print contrast and fonts etc. These do not permit the application of conventional image recognition methods to historical documents. Historical and ancient documents have been preserved in libraries around the world. These documents generally have scientific or cultural importance [1]. To expose these documents safely in public domain such as libraries, it is important firstly to enhance their clarity, visibility and improve the quality. To remove the noise [2] and increase image quality appropriate filtering methods [3] need to be developed. Further, there is a need to apply appropriate image enhancement techniques to enhance the quality of these documents. Image Enhancement improves [4] the clarity of images for human viewing, removes blurring and reduces noise and increases contrast for revealing more details. To maintain the original document persistently [5] it is essential that these documents are transformed into digital form [6]. One of the objectives of this paper is to preserve the historical documents forever. This paper is divided into six sections. Section II states Image Processing Techniques for filtering, enhancement of historical images and the Introduction about the power law transformation. Section III

contains proposed methodology for filtering, equalization and image transformation. Section IV comprised of performance measuring parameters. Section V presents results and discussion of proposed techniques. Conclusion is mentioned at the end of the paper.

II. IMAGE PROCESSING TECHNIQUES

Image processing techniques develop a digital system to analyse and manipulate the digital images for improvement in their quality. Image processing method gives an enhanced image and extracts useful information from it. These techniques process historical images which are more legible for future reference and can be stored digitally. This may help to extend the life of the document. Thus information will be preserved even if the physical document becomes completely obsolete and unreadable in the future. The commonly used image processing techniques for the historical documents images are as follows-

A. Noise Filtering

Noise is any irrelevant information with the textual information of the document image which makes the image blur [7]. Removal of noise from the image is considered as the most important task. Noise Filtering [8] is a well-known technique used for removing the noise present in the image.

Historical document images are subjected to a variety of noises. The noises may include any type of strain, seepage of ink etc [9]. To remove the noise from an image, noise filtering technique leads to smoothing of image.

To supress the low frequencies or high frequencies in an image, filters [10] are long in use. This results in either detecting the edges or smoothing the image. The paper presents the narration of image enhancement techniques with Gaussian noise and filter applied to the noise. The Gaussian filter use probability density function of statistical distribution. Historical Images may have noise as a result of errors in the image acquisition process. As Gaussian smoothening [11] is a low pass filter, it is used to reduce the image's high frequency components. The impulse response of a Gaussian filter is a

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Gaussian function [12] and it modifies the input signal by convolution with a Gaussian function.

As the image is to be stored in the form of discrete pixels, there is a need for discrete approximation to the Gaussian function before performing the Histogram equalisation [13].

In one-dimension the Gaussian Function is mathematically expressed [14] as

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}} \quad (1)$$

Where,

x is grey level value

σ is standard deviation that is distributed

B. Histogram Equalization

Histogram equalization is a process used to equalize [15] the image intensities to enhance the contrast of an input image. Histogram equalization stretches out the intensity range of the document to improve its contrast. It redistributes the intensities of the image of the entire range of possible intensities [16]. Thus, histogram equalization increases the dynamic range of the histogram of an input image. This technique can be used according to the requirement of the image whether may be for the whole image or just on a part of an image [17]. Histogram equalization transforms the intensity values to matches a specified histogram of the output image histogram and [18] is basically used for contrast enhancement. This modification framework uniformly distributes the function by altering the spatial histogram. For input image cumulative distribution function obtains uniformly distributed histogram [19]. During this process insignificant details of image associated with the histogram are discarded. That is one of the main advantages of this process. Visual quality of the data with increase intensity scale is obtained as the result of equalization.

Intensity value [19] of the image which is yet to be processed is taken as *r* which is having the range between [0, L-1].

r = 0, denotes black, *r* = *L -1*, specifies white. Equation (2) represents mathematically histogram of the given input image

$$S = T(r) \quad (2)$$

T(r) is the function which is monotonically increasing having the interval $0 \leq r \leq L\text{-}1$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} 0 \leq r \leq L\text{-}1 \quad (3)$$

Probability Density Function (PDF) of transformed variable s can be obtained by (4)

$$Ps(s) = pr(r)\left|\frac{dr}{ds}\right| \quad (4)$$

Histogram specification improves the quality of information in image by mapping the range of pixel intensity values. Depending on the histogram of input image transformation function is performed followed by manual calculation.

C. Power Law Transformation

Power law transformation is a log transformation technique. Its use for transformation function is called gamma correction. Where, Gamma is the exponent of power law equation. In poor contrast images, the adjacent characters merge during binarization [20]. To reduce the spread of the characters before applying a threshold to the word image different levels of enhancements may be obtained by various values of Gamma. Gamma correction is the process which will rectify and correct the power law response. Power-law transformation increases the contrast of the characters and helps in the better segmentation.

Power law transformation is used for image enhancement process [21]. The basic form of power law transformation is given by following expression

$$S = c.r^{\gamma} \quad (5)$$

Where *c* and γ are positive constants. Power law mapped the thin and darker range input value with the broader range output value which is having fractional values of γ [22]. But if the higher values are to input, then the process works in reverse order. Display of the image and printing the image are the applications done by power law technique [23]. Power law transformation will map the colors and approximate the high dynamic range value [24]. Main objective of this is to rendering the applications. The tone mapping algorithms have two main goals:

1. Preserve all the details of an image.
2. Absolute brightness information for tone mapped on an image provided in a low dynamic range.

The transformation function of an image is based on the input image especially at grey levels. Manual calculation of the histogram is provided with the respective functionality. The histogram of images [25] is partitioned on the basis of local minima of the image and respective grey level intensity values assigned to the pixel. Histogram is partitioned depending on the local minima and grey scale range of an image. After this process, histogram equalization [26] is applied to each level of partition.

III. PROPOSED METHODOLOGY

The proposed methodology provides a means for text preservation and image enhancement for poor quality and degraded document images. In this section the image enhancement process for historical images using noise filtering, histogram equalization, and power law transformation techniques are described in following steps:

A. Step - I

The digital image of the historical document is treated as the standard model for Gaussian noise. Fig. 1 represents the original image having Gaussian noise. Gaussian filter is applied to remove the noise from the image as shown by the filtered image in Fig.2.

Fig. 1. Original Image

Fig. 2. Filtered Image after using Gaussian filter

B. Step – II

For a number of historical images the overall contrast may be improved by histogram equalization method. This technique gives better results, for the cases having the poor contrast, by transformation very close to image data in use. Further, there is a uniform distribution of intensities by adjustment on the histogram. The technique results in higher contrast for the lower level contrast regions. The most frequent intensity values are spread out in an effective way by histogram equalization. Fig. 3 shows the histogram of the filtered image of Fig. 2. This histogram shows the non-uniform distribution of intensifies. The image after histogram equalization and equalized histogram has been shown in Fig. 4 and Fig. 5 respectively.

Fig. 3. Histogram of Fig.1 of input image

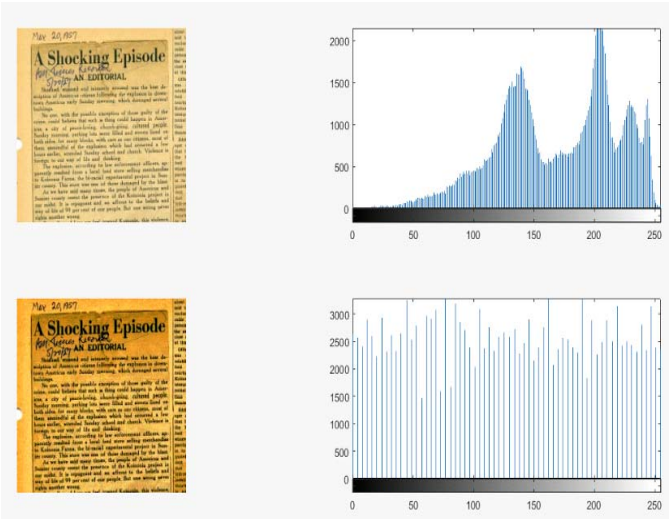

Fig. 4. Histogram of filtered image

C. Step -III

In the proposed work power law transformation function is used to increase the sharpness of the image. It maps the colors and approximates the high dynamic range values. In this transformation technique the enhancement of image varies for different display devices. With increase of degree level to a large value, individual text components may split into multiple components. This reduces the word recognition rate for the word images dataset and creates a poor performance of OCR. As each word image responds differently, to power-law transform, this transformation is being done with different degrees i.e. 0.5, 1 and 2 as shown in Fig. 6, Fig. 7 and Fig. 8 respectively.

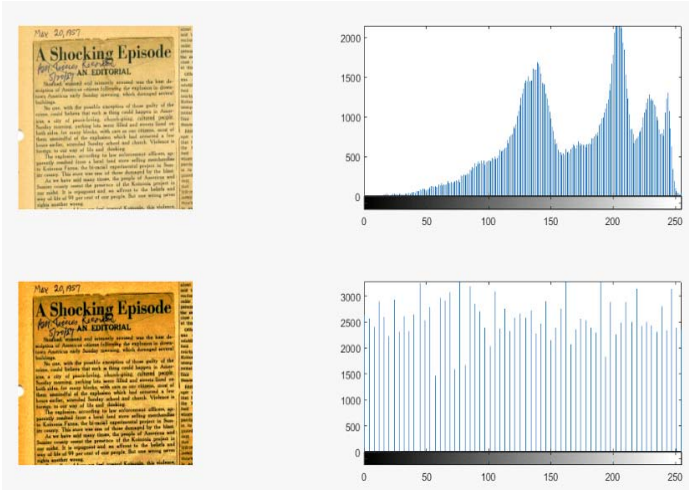

Fig. 5. Image after Histogram equalization

Fig. 6. Power Law transformation with ɣ = 0.5 degree

Fig. 7. Power Law transformation with γ =1

Fig. 8. Power Law transformation with $\gamma = 2$

IV. PERFORMANCE ASSESSMENT

The performance measures provide quantitative comparison among the input image and the processed image. Entropy and standard deviation have been used for performance assessment in this paper.

A. Entropy

Entropy quantifies the amount of information within the image needed for the image enhancement. Entropy measures the loss of information or message in a transmitted signal with image information. If the entropy of an image is high then it is assumed that the image has high image information [26]. If value of entropy of resultant image becomes higher, it indicates better quality. Therefore, larger the value of entropy, better the image. Mathematically entropy is given by

$$E = -\sum_{i=0}^{L-1} p_i \ log_2 p_i \qquad (6)$$

Where L is the total of grey levels, $p = \{p0, p1 \ldots pL-1\}$ is the probability distribution of each level.

B. Standard Deviation

Standard deviation is a quantitative measure used to quantify the amount of variation or dispersion of a set of data values. It is used to measure the statistical dispersion of the contrast in the image also evaluate how widely spread the gray values in an image [26]. It denotes the deviation degree of the estimation and the average of the random variable. An image with high contrast would have a high standard deviation.

Larger the standard deviation, better the result.

$$\alpha = \sqrt{\sum_{i=0}^{L}(i-\bar{i})^2 h_{I_f}(i)}, \ldots \bar{i} = \sum_{i=0}^{L} i h_{I_f} \qquad (7)$$

Where i) is the normalized histogram of the fused image and L is number of frequency bins in histogram.

V. RESULTS AND DISCUSSION

In the proposed work Gaussian filtering and histogram equalization technique have been applied to remove the noise and increase the contrast of the historical images. Further, power law transformation technique has been implemented to increase the sharpness of the historical image. Power law transformation technique is applied with the degree of 0.5, 1, 2. Entropy and standard Deviation have been used as performance measuring parameters to evaluate the quality of original images and resultant images. The analysis of Matlab results (Table I) of original images and resultant images show that the entropy and standard Deviation have been substantially increased after applying the above techniques on input image.

The entropy of input image is 6.1965, after filtering and Histogram Equalization the entropy becomes 6.2019 and 6.4890 respectively. After applying Power law Transformation on the above image, the entropy further increases to 6.9504. This entropy obtained is very high in comparison to entropy of initial input image.

The Standard Deviation of input image was 22.0092. After applying filtering and Histogram Equalization the Standard Deviation becomes 22.0094 and 22.0095 respectively. Further, application of Power law Transformation on the above image yields in increase in Standard Deviation to 22.106.

TABLE I: Analysis of Different Stages of Images with Measuring Parameters

Types of Images	Measuring Parameters	
	Entropy	Standard Deviation
Original image	6.1965	22.0092
Image after Filtering	6.2019	22.0094
Image after Histogram Equalization	6.4890	22.0095
Image after Power Law Transformation	6.9504	22.106

VI. CONCLUSION

In this paper, image enhancement has been used for upkeep and overall improvement in the quality of digital images obtained from historical images. In the proposed work, Gaussian filter has been used to remove the noise from the historical document in the form of stain, yellow background. Further histogram equalization is used to enhance the image; power law transformation is implemented to sharpen the image. Entropy and Standard deviation show that the image obtained after power law transformation is the best output image. The proposed techniques combined may be utilized to keep the digital record of the historical documents by libraries and to provide access to general public with higher amount of precision. This process may be utilized in the framework of libraries willing to provide public access to their collection of historical documents.

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