



Research Manuscript Title

Multispectral Image Restoration of Historical Document Images

R. Kiruthika,

*P.G. Scholar, ME. Communication systems,
Department of ECE,
Sri Venkateswara College of Engineering.*

E-Mail: kirtikarajendran@gmail.com

Mrs. S. Kalyani,

*Assistant Professor,
Department of ECE,
Sri Venkateswara College of Engineering*

kalyani@svce.ac.in

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R. Kiruthika , student,
ME. Communication systems,
Department of ECE,
Sri Venkateswara College of Engineering.
kirtikarajendran@gmail.com

Mrs. S. Kalyani,
Assistant Professor,
Department of ECE,
Sri Venkateswara College of Engineering
kalyani@svce.ac.in

ABSTRACT

Culture is preserved through various documents which is a part of the civilization and heritage. Due to extinction and single document copies available for the future generations about the ancient scripts, the archiving of these documents in the digital process is the solution for these problems. In this paper, the aim is to restore the historical document from tears, stains and poor visibility using multispectral imaging tool. The proposed system consists of image fusion, binarization using niblack algorithm and restoration using inpainting process using multispectral imaging tool. The binarization process is done using adaptive thresholding niblack algorithm. The inpainting process fills the missing holes, degraded areas and stains and restores the image. Thus the image can be restored from its degraded condition and is enhanced to remove noise, tears and ink bleed.

Keywords: *inpainting, binarization, multispectral imaging, image fusion.*

1. INTRODUCTION

Culture and customs are considered to be an important resource of a country and plays a pivotal role in the country's development in both cultural and economic terms. The ancient culture is preserved through historical documents and makes a trending study in the preservation of heritage. The historical documents has to be digitally archived in order to preserve the content as the degradation of these documents occurs due to time lapse. The degradation problems are mainly due to tears, ink bleed or seep through and interfering patterns which makes a major obstacle when they are used to read. These types of problems mainly occur due to various types of ink used in the writing of text in these documents.

Ancient manuscripts constitute a significant portion of cultural heritage, which are unique, with mainly only single copies available. These copies have a serious risk of loss and extinction and suffer from many forms of deterioration and physical degradations due to a combination of several factors such as environmental conditions, tearing, dust particles, dirt, rusty staples, poor and risky handling during storage, poor ways of sorting the drawers, effects of natural disasters or accidents, improper assembling during archiving, low quality of the paper, insects and rodents, darkness-illumination levels and air pollution, humidity causing mold and discoloration of historical document papers, etc



Figure.1 Examples of Historical document images

In the recent trends, the multispectral imagery tool is used in the restoration projects by exploiting its properties of various wavelengths. The historical documents which are scanned and archived can be restored using this multispectral imaging tool to the original quality of the document. They can be further enhanced and the text is extracted using this imaging tool. The degraded document is analysed using different patterns such as text, interference and background illumination. The quality of these scanned documents can be used to improve by segmenting different layers and analyzing their spectral properties at different wavelengths. In this paper, we use the multispectral imaging tool to analyse the various different layers and to fuse the different wavelengths of images to find the foreground and background estimation. The next step is to implement the binarization which is used to create a binary mask for further in inpainting process. The enhancement process includes the morphological operations of dilation and closing to reduce the noise in the foreground and to increase the enhancement efficiency.

2. LITERATURE SURVEY

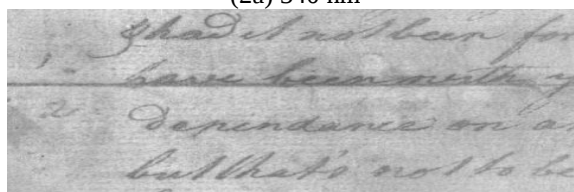
[2] In the recent paper of Racheid and Hedjam, a new algorithm is developed to restore and enhance the visual quality of degraded historical document images collected from the BAnQ. When few spectral bands are available (i.e., with a simple gray level or color space), we have first noticed that it is very difficult to find an efficient segmentation strategy for correctly estimating the different (classes or) objects (i.e., TEXT/INK, BACKGROUND and various DEGRADATIONS) of the historical documents, which will be then useful in our subsequent unsupervised restoration model. In a simple classification method to separate and extract the main pattern (foreground text) from the multispectral images of degraded documents, in order to overcome the limitation of the conventional binarization methods that perform on gray level images. The results, are compared to the state-of-the art and are taken to be promising.[2] In the paper of optimizing via scale map, it proposes a two stage image restoration framework using optimum scale map considering smoothing, edge preservation and guidance strength. The first stage involves the restoration algorithm and the second stage of the multispectral imaging restoration system involves the shadow removal of the images. The shadow removal system consists of median filter and Laplace of Gaussian (LoG) filter system. In [3], the paper produces a estimation of the background surface of the document through an iterative procedure of polynomial smoothing method. In this paper, the authors exploit a multispectral image representation to perform more accurate document image binarization compared to previous color representations. In the first stage, image fusion is employed to create a “document” and a “background” image. In the second stage, the Fast ICA Algorithm is used to perform background subtraction. In the third stage, a spatial kernel K-harmonic means classifier binarizes the Fast ICA output. In the final post-processing stage, small-size 8-connected clusters are removed to eliminate possible binarization noise. The proposed system outperforms previous efforts on document image binarization.

3. PROPOSED WORK

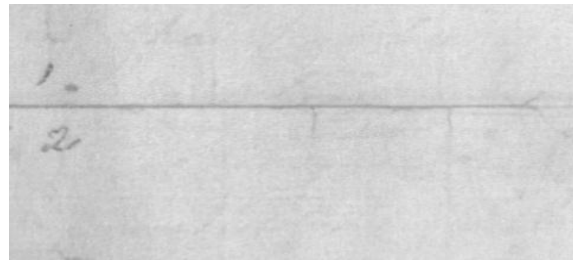
In this paper, the multispectral imagery tool is used in the restoration methodology for historical document images. The output of multispectral imaging consists of wavelengths like ultra violet (UV), visible light(VIS),infrared(IR),etc. A scanned historical document consists of information such as foreground, background and degradation layers which are superimposed to form a single scanned image. The degradations are classified as slight and strong degradations. The slight degradation consists of noise, paper folds and tears. The strong degradations occur due to objects or color which is closely to the main text and sometimes stamps, tears and also ink bleed. Image Fusion is a technique which combines complimentary information from different images of the same scene so that the fused image is more suitable for segmentation, feature extraction, object recognition and Human Visual System.



(2a) 340 nm



(2b) 500nm



(2c)1100nm

Figure 2. Examples of various wavelengths

Image fusion has emerged as a promising research area. Hence, image fusion is the process by which we combine two or more images into single image having important features from all. This fused image contains a more accurate description of the scene than any of the individual source images. In the recent years, fusion methods based on image gradient pyramid and multi resolution analysis become very popular. The basic idea behind these methods is that source images are decomposed by applying pyramid or wavelet transforms, then fusion operation is performed on the transformed images. These methods produce very good results in less computation time and less memory. The goal of image fusion is to achieve the best possible quality for fusion process. No single quality measurement method had gained universal acceptance, however, two measurement methods have dominated the assessment of image quality, which are computable objective distortion measure and subjective quality as measured by visually evaluation.

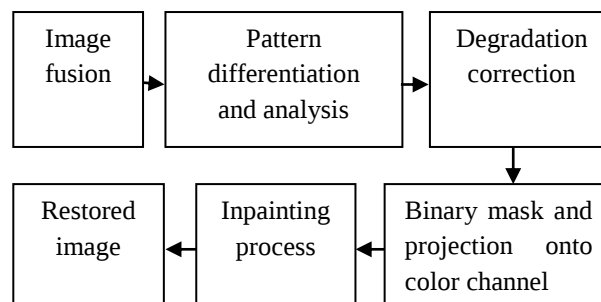


Figure 3. Block diagram of the proposed system

The wavelet packet transform (WPT) generalizes the discrete wavelet transform and provides a more flexible tool for the time-scale analysis of data. All advantages of the wavelet transform are retained because the wavelet basis is in the repertoire of bases available with the wavelet packet transform. Given this, the Wavelet packet transform may eventually become a standard tool in signal and image processing. In case of the degradations, the strong degradations are eliminated using the inpainting problem. But in the slight degradations the problem can be mainly eliminated property of the multispectral wavelengths. The most distinct IR band will allow to estimate the essential function, which represents a two-distinct step segmentation map or a binary mask in which the pixels in the degraded area can be represented as the value 0 and the foreground or useful content is represented as the non degraded or pixels containing useful information. Binarization is the beginning step of the restoration framework. It forms the pivotal step in the extraction of text document. It forms the strong foundation for the restoration and enhancement of text documents. The global thresholding method uses a single value to classify the image pixels into the different classes and the local thresholding are adaptive which uses multiple values.

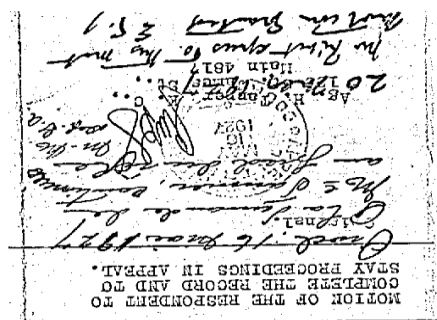
Niblack's algorithm uses a window using the pixel wise threshold by shifting the rectangular window across the image. The threshold T for the center pixel of the window is computed using the mean m and the variance s of the gray values in the window:

$$T = m + k s \quad (1)$$

Where k is a constant set to -0.2. The value of k is used to determine how much of the total print object boundary is taken as a part of the given object.

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Lin Uliad

(4a)



(4b)

Figure 4. examples of binarization

Inpainting is the process of recognizing and recovering an image from its degraded form. The main objective of inpainting process is to remove the unwanted regions from the degraded images. The algorithm of the inpainting process automatically fills the selected regions with the information of the pixels surrounding them. The filling process is done as the lines in the boundaries are completed in the inside part. The process is very automatic and done in quick time. The total variation inpainting is one of the important tools in the recovery of noisy and the corrupted ones. This involves the faster restoration and rebuilt area which are in close resemblance to the original image.

4. RESULTS AND DISCUSSION

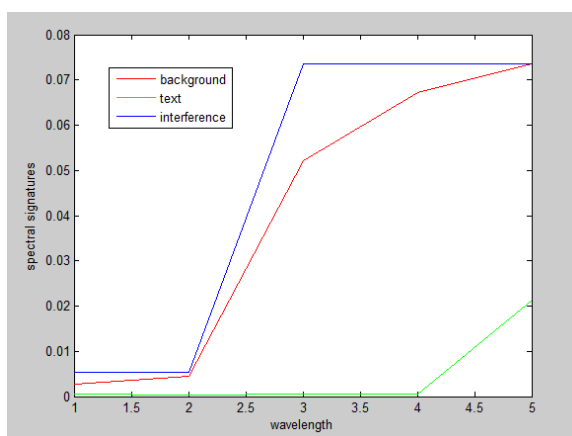
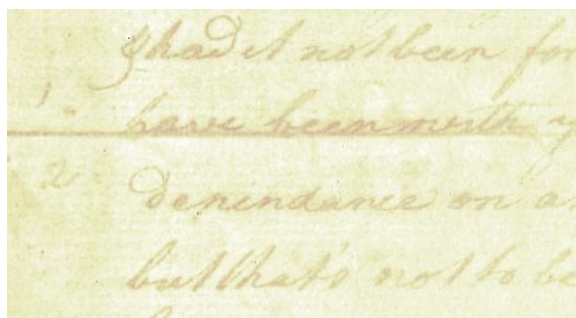


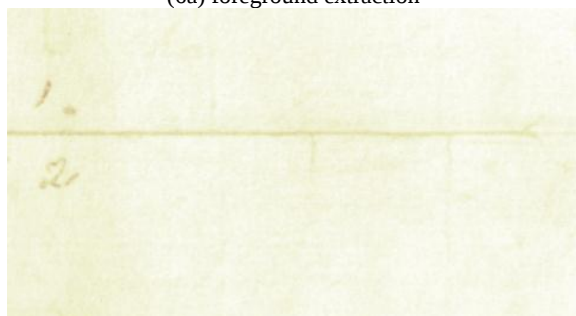
Figure 5. plot for different patterns

From the simulated plot of spectral signatures for different patterns obtained above, the comparison can be easily done for the different ink patterns, interference and degradations. Then the fusion for the degraded images are done based on the correction process involved. The statistical parameters involved for the analysis of degradation are mean, variance and

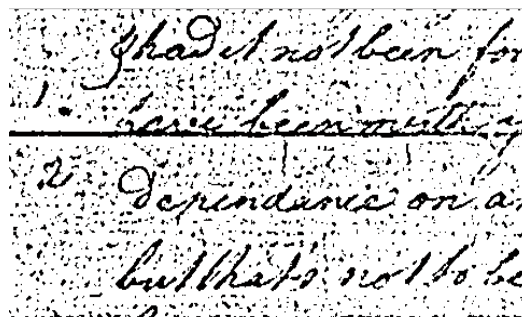
standard deviation of text, background and interference. The statistical parameters are plotted against the spectral signatures of different wavelength.



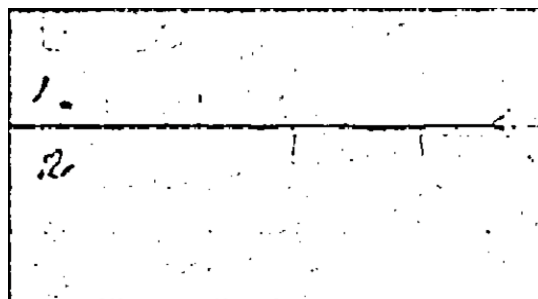
(6a) foreground extraction



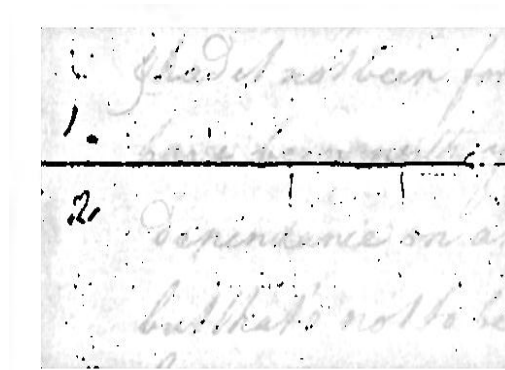
(6b) background extraction



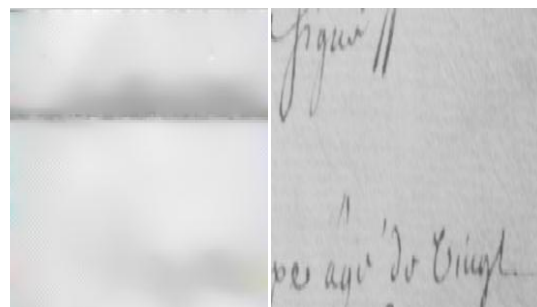
(6c) Noisy binarized image



(6d) Binary mask for projection



(6e) Binary mask projected onto color channel



(6f). Results of the inpainted image
Figure 6. Results of proposed system

The simulated result images are the denoised image and the TV inpainted image. The inpainted image is as a result of the degraded cropped

TABLE. 1. Performance measures: binarization

	Otsu threshold	Niblack method	Proposed work
Mean square error	2.751	2.530	2.218
PSNR	60.83	81.75	85.54

image where the total variational inpainting in which the process is done using the degraded image and binary mask. The performance measures for the images are calculated in the table above.

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [I(i,j) - K(i,j)]^2 \quad (2)$$

Where I is the monochrome image and K is its noisy approximation.

$$PSNR = 10 \log_{10} \left(\frac{Rn * Cn}{MSE} \right) \quad (3)$$

Where Rn is the number of rows and Cn is the number of columns in an image.

5. CONCLUSION

The digital archiving of ancient and historical documents is an expanding trend in the study and preservation of cultural heritage and is a task that requires the enhancement and restoration of the images to be processed, regardless of the quality of the acquired images. In this project historical documents which are archived can be restored using the proposed

algorithm. The intensity of degradation is reduced using the classification of different patterns and the image fusion process using the multispectral imaging. Then the image is restored using the binarization and the total variation inpainting process.

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