Restoration of Degraded Historical Document Image

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ABSTRACT

Restoration plays a very important role in enhancing the degraded noisy images. To enhance the degraded image, the numerous algorithms have been designed. Since image processing algorithms are subjective, not all algorithms that developed will address all type of degradedness. To address specific type of problem the suitable algorithms need to be selected. In this paper a combination of spatial domain method along with set theory operations are used to enhance the historical image. The proposed method eliminates noise, uneven background and enhances the contrast of the script image. The result of the proposed method is compared with Mean and Gaussian filter. Performance of the proposed method proved to be better than these methods. The restored images will have clear uniform background and foreground with enhanced character appearance.

Keywords: Bilateral Filter, contrast Enhancement, Denoising, Degraded Document, Historical, Spatial Domain.

1. INTRODUCTION

It is very important to preserve the historical documents which reveal the information about the civilized past. These documents are available in various forms like stone and metal carvings, palm leaf manuscripts, paper manuscripts. These documents pose many degradation due to weather conditions, method of preservations etc. Stone carvings also referred to as epigraphically scripts are the oldest among all forms of communication in olden days. It is found from the archeological department that the epigraphically scripts belonging to 3rd century BC are also available and maintained. But not all available ones are in good condition. To preserve this information for longer period, one needs modern tools and techniques.

Another oldest medium of writing and communicating in South Asia are palm leaf manuscripts. These are also the major sources for writing and painting in South East Asian countries including Thailand, Nepal, India, Barma, Indonesia etc.[Uday Kumar et. al 2009]. Hence it is required to develop an automated system to decipher these inscriptions. The system takes the camera grabbed or scanned images of the inscriptions as an input and processes it before the character recognition is taken up. The images so captured have major problems like the broken letters, erased letters, distortion due to fossils settled and so on. The presence of unwanted marks engraved by the sculptor leads to wrong diagnosis of inscriptions. Hence this requires a lot of preprocessing before the character recognition is taken up.

The need for efficient image restoration methods have grown with the massive production of digital images of all kinds, often taken in poor conditions. Even though good cameras are available, images may not be in a condition to directly use for the analysis. From the literature survey, it is observed that, there are several techniques like moving average filter, Gaussian filter for noise suppression are available. However, the techniques effectively suppress the noise but fail to preserve many useful details. In the past decades, many researchers shown considerable interest in using the wavelet transform as a powerful tool for recovering signal from noisy data and method is generally referred to as wavelet shrinkage techniques. In 1995, Donohue presented a soft thresholding method for denoising in 1-D signal using wavelets pyramidal filtering. Chang, Yu and Vetterli [2000] introduced an adaptive wavelet thresholding for image denoising and compression.

Shijian Lu et. al.[2007] proposed technique which estimates document background surface using an iterative polynomial smoothing procedure. Various types of document degradations are then compensated by using the estimated document background surface intensity. Using L1-norm image gradient, the text stroke edge is detected from the compensated document image. Finally, the document text is segmented by a local threshold that is estimated based on the detected text stroke edges. Napa Sae-Bae and Somkait Udomhunsakul [2007] presented adaptive BSVD method to denoise the image. It is found that these techniques alone cannot improve the visibility of the degraded images.

Ntugas et al. [2008] proposed binarization procedure consisted of five discrete steps in image processing, for different classes of document images. A refinement technique enhances further the image quality. The main contribution of this paper was to propose a simple and robust binarization procedure for pre-filtered historical manuscripts images, and simulation results are also presented. E. Badekas et. al. [2009] proposed a new method which the estimates the best parameter values for
each one of the document binarization techniques and also the estimation of the best document binarization result of all techniques. Yahia S. et. al. [2009] presented an enhanced system for degraded old document. The developed system was able to deal with degradations which occur due to shadows, non-uniform illumination, low contrast and noise. The developed system was able to separate the two regions of the document. Laurence Likforman-Sulem [2011] presented novel method for document enhancement which combines two recent powerful noise-reduction steps. The first step was based on the Total Variation framework. And second step was based on Non-Local Means. Non Local Mean filter computational complexity depends on the size of the patch and window.

The paper is organized as follows: Section 2 presents the brief introduction of bilateral filter. Mathematical morphology is explained in the section 3. The proposed method is detailed in section 4. Section 5 reports experimental results and section 6 provides concluding remarks.

2. BILATERAL FILTER

We briefly review the bilateral filter in this section. Bilateral filter is a non linear filter in spatial domain, which does averaging without smoothing the edges [Ming Zhang 2009]. The bilateral filter takes a weighted sum of the pixels in a local neighborhood; the weights depend on both the spatial distance and the intensity distance. Actually the bilateral filter has weights as a product of two Gaussian filter weights, one of which corresponds to average intensity in a spatial domain, and second weight corresponds to the intensity difference. Hence no smoothing occurs, when one of the weights is close to 0. It means, the product becomes negligible around the region, where intensity changes rapidly, which represents usually the sharp edges. As a result, the bilateral filter preserves sharp edges [Jinwook Kim et al 2009].

Mathematically, at a pixel location $x$, the output of a bilateral filter is calculated as follows,

$$\hat{I} = \frac{1}{C} \sum_{y \in N(x)} e^{-\frac{||y-x||^2}{2\sigma_d^2}} e^{-\frac{||f(y) - f(x)||^2}{2\sigma_r^2}} I(y)$$

(1)

where $\sigma_d$ and $\sigma_r$ are parameters controlling the fall-off of weights in spatial and intensity domains, respectively. $I$ and $\hat{I}$ are input and output images respectively. $N(x)$ is a spatial neighborhood of pixel $I(x)$, and $C$ is the normalization constant:

$$C = \sum_{y \in N(x)} e^{-\frac{||y-x||^2}{2\sigma_d^2}} e^{-\frac{||f(y) - f(x)||^2}{2\sigma_r^2}}$$

(2)

3. MATHEMATICAL MORPHOLOGY

From past five decades, many image-processing techniques have been developed and their applications in real world are tremendous. One among many techniques is the mathematical morphology, which is continuously receiving great attention.

Since it provides a quantitative description of geometric structure and shape as well as a mathematical description of algebra, topology, probability, and integral geometry, it has been enormously useful in many image processing and analysis applications. Mathematical morphological operations are based on simple set theory concept. These operations are non linear operations and can be used to extract shape features such as edges, holes, corners, wedges, and cracks by operating with structuring elements of varied sizes and shapes. They are also used to break thin isthmus and fill the gaps between bridges. Morphological operations can be employed in enhancement, preprocessing, segmentation, feature extraction, pattern classification, etc.

The two basic operations dilation and erosion are the fundamental building block of all other morphological operations. The morphological operations require two components, one is the input image and another one is the structuring element. Based on the type of problem structuring element will be selected. Since these operations are based on the simple set theory concept, the computational complexity will be less.

Binary mathematical morphology uses binary image data and performs Boolean operations. Gray scale morphology uses gray scale image and uses min max theory to select the intensity of the output image. The detailed study of mathematical morphology is again not in the scope of our paper.

4. PROPOSED METHODOLOGY

The proposed method is combines two powerful image processing techniques, one spatial filtering technique and gray scale mathematical morphology. The proposed method takes degraded historical document as input and performs series of the step as explained below in detail.

The camera grabbed image is converted into gray scale image shown in Fig 1. Fig. 2 shows the binarized image of the degraded document image. Then bilateral filter
is applied to the input image. Result of the bilateral filter is shown in Fig. 3. The image is filtered without smoothing the edges. As mentioned in the section 2, bilateral filter filters the image without smoothing the edges. This preserves edges and filters out the noise. Mathematical reconstructions operations are done along with contrast enhancement. Gray scale opening is applied with disk structuring element and result image is added to the bilateral filtered image.

Mathematical dilation is applied to enhance the image and shown in Fig 6.

Global thresholding method is applied to binarize the result image and is shown in fig 7.

Filtered image is subjected to gray scale opening followed by closing. Resultant image is added to filtered image. Result is added back to filtered image to get reconstructed image. To eliminate background, we need to normalize the background intensity. Using Gaussian filter with 50 window size and 30 standard deviation, the reconstructed image is blurred and result(blurred) image is subtracted from filtered image. Again result image is added to filtered image and reconstructed image to get the enhanced image as in Fig 5.

5. RESULTS AND DISCUSSION

The proposed method is used to enhance the palm script and epigraphically script images. Experimentation has been performed on the set of more than 200 images of various sizes. The camera grabbed images are used with size varying from 3000x4500 to 300x450. Length and width of the palm scripts are varying from 40 inch to 2 inch and from
The proposed method enhances the degraded image with uniform background. The enhanced document image can be used further to segment the document into lines, words and character for recognition purpose. So preprocessing stage plays very important role in pattern recognition. Properly binarized image increases the performance of the segmentation algorithm. From correctly segmented character, valid features can be extracted from feature extraction techniques. Classifier performance is entirely depends on the extracted features. So enhancement of the degraded documents is must in preserving them in digital format and/or hard copy, and understanding the document contents. Some of the experimental results are shown here.

5. CONCLUSION

Historical documents are usually pose many degradations, due to weather condition, preservation and handling methods, etc. Image processing techniques are required to address these issues and to preserve of documents, as these provide valuable information about our culture. Simple and computationally efficient hybrid algorithm is proposed using a combination of bilateral filtering and set theory approach. Bilateral filter is an efficient in eliminating the noise without smoothing the edges. Mathematical morphology which is based on set theory approach uses simple operations which are computationally less complex. Morphological operations are very much useful in bridging gap between broken parts of the character. The proposed method is compared with average and Gaussian filter. Results show that the proposed method performs better than compared methods in enhancing the degraded document image.

Fig (8) a) Result of mean filter, b) Result of Gaussian filter c) Result of proposed method. Fig d), e) and f) are the binarized of Fig a), b) and c)
Figure 9 (a): input image (b) Binarized input image (c) Enhanced image using proposed method and (d) Binarized image of the enhanced image.
Figure 10: (a) Input image (b) Binarized input image (c) Enhanced image using proposed method and (d) Binarized image of the enhanced image.
REFERENCES


