Performance Analysis on Point Operations Based Image Enhancement for Document Images

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Abstract

The purpose of image enhancement is to improve the perceptibility of information contained in an image. Contrast enhancement is one of major issue in document image analysis and it is essential to do further document processing and analysis. Contrast is the difference in visual properties that makes an object (or its representation in an image) distinguishable from other objects and the background. In visual perception of the real world, contrast is determined by the difference in the color and brightness of the object and other objects within the same field of view. In this paper we have analyzed the spatial domain coordinates for contrast enhancement in document images. The basic point processing methods are (i) Contrast stretching (ii) Bit plane slicing and (iii) Histogram Equalization and we have evaluated the methods with the images of TOBACCO standard database

1. Introduction

The objective of enhancement is to process an image so that the result is more suitable than the original image for a specific application. The word specific is important, because it establishes at the outset that the techniques are oriented to the problem. Regardless of the method used, however, image enhancement is one of the most interesting and visually appealing areas of image processing. Image enhancement approaches fall into two broad categories: Spatial domain methods and frequency domain methods. The term spatial domain refers to the image plane itself, and approaches in this category are based on direct manipulation of pixels in an image. Frequency domain processing techniques are based on modifying the Fourier transform of an image. In this paper we have analyzed the spatial coordinates for the enhancement of document images. In the spatial coordinates we have selected three different approaches for contrast enhancement under point operations. The basic point processing methods are (i) Contrast stretching (ii) Bit plane slicing (iii) Histogram Equalization technique. We have evaluated the methods with the document images standard database.

2. Enhancement Techniques

Image enhancement is a process of improving the visual appearance of image by improving with its features. Here we have compared three different methods for image enhancement[4] for document Images (i) Contrast stretching (ii) Bit plane slicing and (iii) Histogram Equalization. A number of contrast measures were proposed for complex images as document images [2]. During image acquisition [1] the images are affected due to poor illumination, lack of dynamic range in the imaging sensor, or even wrong setting of a lens aperture etc. To overcome this we have to increase the dynamic range of the gray levels in the image being processed.

3. Contrast Stretching

One of the simplest piecewise linear functions is a contrast-stretching transformation. Low-contrast images can result from poor illumination, lack of dynamic range in the imaging sensor, or even wrong setting of a lens aperture during image acquisition [5]. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed.

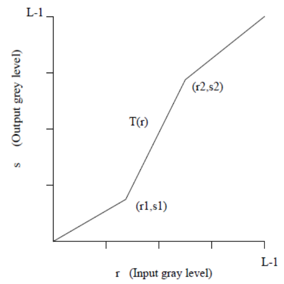


Fig 3.(a) Transformation Function

The locations of points (r1, s1) and (r2, s2) control the shape of the transformation function. If r1=s1 and r2=s2, the transformation is a linear function that produces no changes in gray levels. If r1=r2, s1=0 and s2=L-1, the transformation becomes a thresholding function that creates a binary image. Intermediate values of (r1, s1) and (r2, s2) produce various degrees of spread in the gray levels of the output image, thus affecting its contrast. In general, r1 ≤ r2 and s1 ≤ s2 is assumed so that the function is single. Valued and monotonically increasing. This condition preserves the order of gray levels, thus preventing the creation of intensity artifacts in the processed image. The general form is

$$v = \begin{cases} \alpha u, & 0 \le u < a \\ \beta(u-a) + v_a, & a \le u < b \\ \gamma(u-b) + v_b, & b \le u < L \end{cases}$$

(Eq.2.5.2)

where r are the input image values, s are the output image values, m is the thresholding value and E the slope

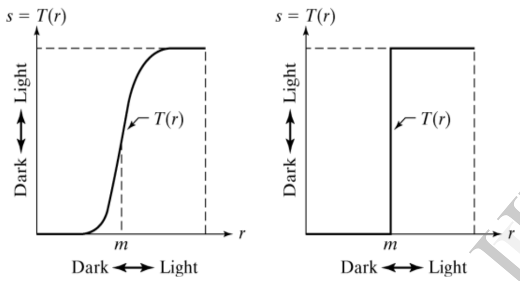
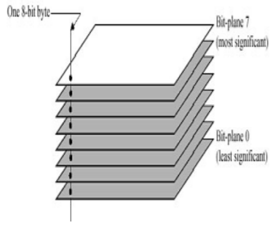


Figure it show the effect of the variable E, if E = 1 the stretching became a threshold transformation, if E > 1 the transformation its defined by the curve which is smoother when the E value is increase, and when E < 1 the transformation makes the negative and also stretching.

4. Bit Plane Slicing

Instead of highlighting intensity ranges, highlighting the contribution made to the total image appearance by specific bit might be desired. Imagine that the image is composed of eight 1-bit planes, ranging from plane 0 for least significant bit to plane 7 for the most significant bit[5].

Bit-plane slicing reveals that only the five highest order bits contain visually significant data. Also, note that plane 7, corresponds exactly with an image threshold at grey-level 128.



5. Histogram Equalization

Histogram equalization method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity valuesis a one among the best method in image processing for contrast adjustment using the image's histogram[4][5]. A better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. A key advantage of the method is that it is a fairly straightforward technique and an invertible operator.The calculation is not computationally intensive.

The histogram of a digital image with grey values

$r_0, r_1, \cdots, r_{L-1}$ is the discrete function

$$p(r_k) = \frac{n_k}{n}$$

nk: Number of pixels with gray value rk

n: total Number of pixels in the image

The function p(rk) represents the fraction of the total number of pixels with gray value rk. Histogram provides a global description of the appearance of the image. If we consider the gray values in the image as realizations of a random variable R, with some probability density, histogram provides an approximation to this probability density. In other words

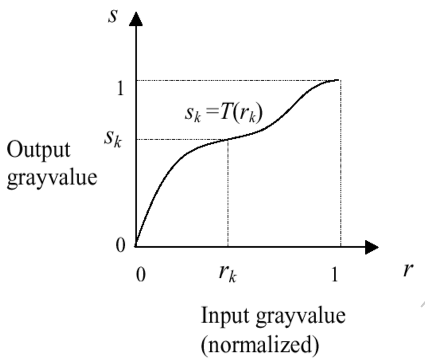
$$\Pr(R = r_k) \approx p(r_k)$$

The histogram equalization is an approach to enhance a given image. The approach is to design a transformation T(.) such that the gray values in the output is uniformly distributed in [0, 1]. Let us assume for the moment that the input image to be enhanced has continuous gray values, with r = 0 representing black and r = 1 representing white. We need to design a gray value transformation s = T(r), based on the histogram of the input image, which will enhance the image.

As before, we assume that:

(1) T(r) is a monotonically increasing function for 0 £ r £ 1 (preserves order from black to white).

(2) T(r) maps [0,1] into [0,1] (preserves the range of allowed Gray values).



Let us denote the inverse transformation by r = T -1(s). We assume that the inverse transformation also satisfies the above two conditions. We consider the grey values in the input image and output image as random variables in the interval [0, 1]. Let pin(r) and pout(s) denote the probability density of the Gray values in the input and output images.

If pin(r) and T(r) are known, and r = T -1(s) satisfies condition 1, we can write (result from probability theory):

$$p_{out}(s) = \left[p_{in}(r) \frac{dr}{ds} \right]_{r=T^{-1}(s)}$$

One way to enhance the image is to design a transformation T(.) such that the grey values in the output is uniformly distributed in [0, 1], i.e. pout (s) = 1, 0 £ s £1.

In terms of histograms, the output image will have all gray values in “equal proportion”. This technique is called histogram equalization.

6. Document Images

Document image Enhancement is necessary in many situations when we are analysing the quality of the documents including checks, hand-written text, credit card receipts become noisy and low-contrast images after scanning. Contrast Enhancement is one of the major issues in Document Image Analysis. Due to high or low contrast on images various types of need based analysis tasks are getting complicated. Solution for such type of images is to improve such images by reducing noise and increasing the contrast of the text. This can be achieved by incorporating point operations.

7. Experiment Results

In this section we have compared the performance of all algorithms according to three parameters[2](i) Image Brightness mean, (ii) Image Contrast – standard Deviation, (iii) Peak Signal to Noise Ratio (PSNR). These equations are referred from the histogram equalization methods for contrast enhancement and brightness [4]. The results shown in Result Table exhibit the brightness preserving capabilities of various methods considered in this paper. By observing the absolute difference between the value of brightness in the original images and the processed images (i.e., the brightness preservation), we state that: 1) the images produced by Contrast Stretching method is better in preserving the brightness; 2) Even though Contrast Stretching method not always the best brightness preserving ones, their resulting brightness is always very close to the brightness of the original images in the table it is shown as a grey shaded area. Apart from this method, Bit – Plane Slicing is also close to the image mean brightness. If we analyse the results in Table by observing the contrast values, we find that: 1) Bit – Plane Slicing (Plane = 6) method produces overall the best image contrast enhancement. 2) Besides this method Contrast Stretching also produce good results for image contrast enhancement 3) The Histogram Equalisation method produces relatively small image contrast enhancement.
Finally we analyse the data presented in table, which shows the abilities of various methods to produce natural looking images. For the best value of PSNR it should be as much as possible. We observe that the images processed by the Contrast Stretching method produce the best PSNR values. After that Bit – Plane Slicing (Plane = 6) shows better result. As we know that for high PSNR the signal should be as high as possible and noise should be as small as possible. But in case of contrast enhancement the noise is the

variation of pixel value and if its variation is less then it is not possible to increase the contrast of digital image. So Bit – Plane Slicing (Plane = 6) even though has have best PSNR, it does not produce good contrast. Moreover, it does not preserve brightness as well. Hence when our aim is to enhance the contrast then we can neglect the PSNR.

After analysing the data presented on table and visually observing some processed images, we can conclude that: 1) The Contrast Stretching method produces better images contrast and also preserve the brightness with better quality than the other methods; 2) However, a better PSNR can be obtained by the Bit – Plane Slicing (Plane = 6) method. Image Brightness-Mean

$$\left(\mu = \sum_{l=0}^{L-1} l \times p(l)\right),$$

Image Contrast Standard-Deviation

$$\left(\sigma = \sqrt{\sum_{l=0}^{l-1} (l-\mu) \times p(l)}\right),$$

$$\text{PSNR} = 10 \times \log 10 (L-1)^2 / \left(\frac{1}{l1l2} \sum_{i=1}^{l1} \sum_{j=1}^{l2} \| yij - oij \|^2\right).$$

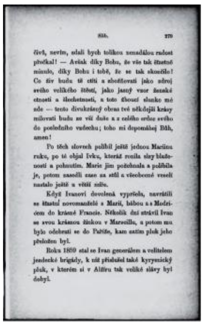
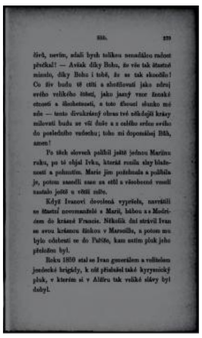


Fig 4.(a)



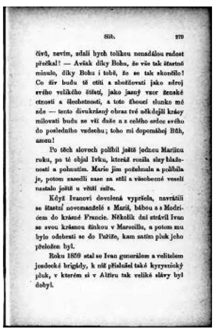


Fig4.(b) **Fig 4.(c)**

Fig 4. (a) Original Image (b) Grayscale Image with contrast (c) Contrast Enhanced image using Contrast Enhancement method.

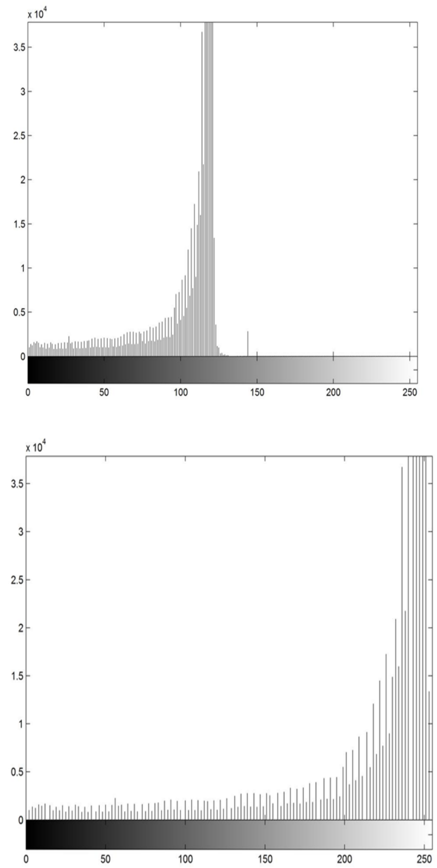
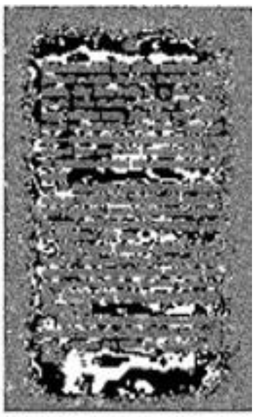


Fig 5. (a) Histogram of Grayscale Image with contrast (b)Histogram of Contrast Enhanced image using Contrast Enhancement method

Bit Plane Slicing

Bit Plane 0



Bit Plane 1

Bit Plane 2

Bit Plane 3

Bit Plane 4

Bit Plane 5

Bit Plane 6

Bit Plane 7

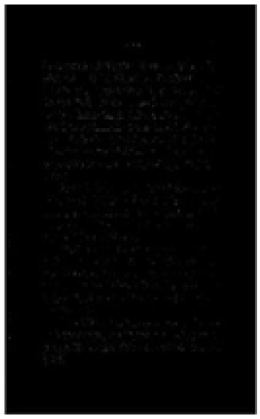
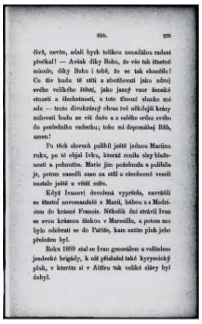
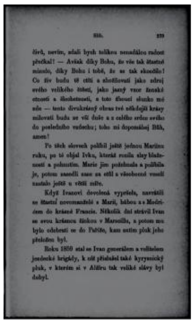


Fig 6. With the bit plane value range 0 to 7.

Histogram Equalization





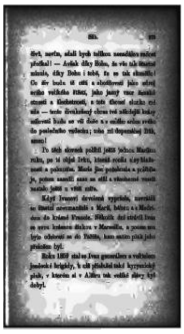


Fig 7. (a) Original Image (b) Grayscale Image with contrast (c) Contrast Enhanced image using Histogram Equalization method.

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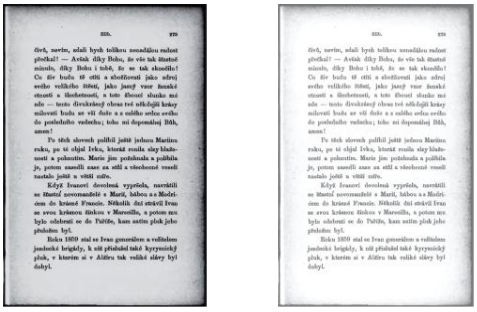


Fig 8. (a) Original Image (b) Contrast Enhanced Image with Histogram equalization method.

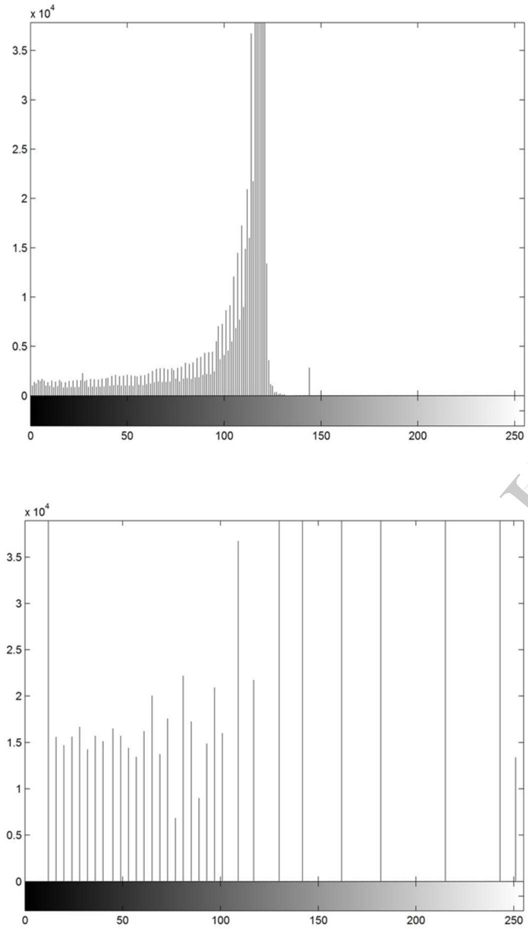
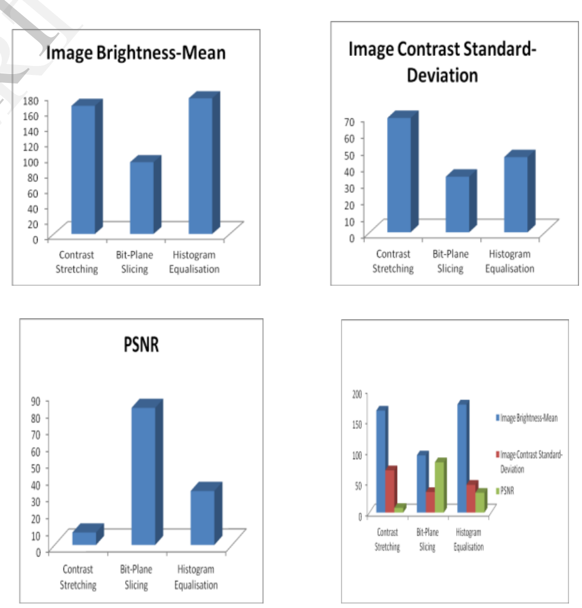


Fig 9. (a) Histogram of Grayscale Image with contrast (b) Histogram of Contrast Enhanced image using Histogram Equalization method.

Result:

Methods / Parameters	Image Brightness-Mean	Image Contrast Standard-Deviation	PSNR
Contrast Stretching	**166.22**	**68.77**	**7.4143**
Bit-Plane Slicing	**93.11**	**33.42**	**81.79**
Histogram Equalisation	**176.12**	**45.222**	**32.22**

Table: Comparison of (i) Contrast Stretching (ii) Bit-Plane Slicing (iii) Histogram Equalisation methods with the parameters (i) Image Brightness-Mean (ii) Image Contrast Standard-Deviation and (iii) PSNR.



8. CONCLUSION

In this paper we have analysed three different algorithms for contrast enhancement of document images. In general, it is observed that contrast enhancement and high PSNR are two conflicting requirements. The performances of various algorithms are compared according to three parameters namely, Image Brightness Mean, Image Contrast-Standard Deviation and PSNR. It is observed that Contrast Stretching algorithm produces the best image contrast enhancement among all whereas Bit- Plane Slicing and Histogram are next two algorithms producing good image contrast enhancement.

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