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COMPARATIVE STUDY OF DIFFERENT IMAGE ENHANCEMENT TECHNIQUES

Saruchi
University College of Engineering,
Punjabi University Patiala (Punjab) INDIA

Madan Lal
Punjabi University Patiala(Punjab),India

ABSTRACT

The main purpose of image enhancement is to bring out detail that is hidden in an image or to increase contrast in a low contrast image. Image enhancement techniques provide a multitude of choices for improving the visual quality of images. Appropriate choice of such techniques is greatly influenced by the imaging modality, task at hand and viewing conditions. This paper analyses the performance of some of existing image enhancement algorithms. The performance of algorithms is evaluated both qualitatively and quantitatively.

1. INTRODUCTION

Digital images play an important role both in daily life applications such as satellite television, magnetic resonance imaging, computer tomography as well as in areas of research and technology such as geographical information systems and astronomy [2]. Whenever an image is converted from one form to other such as digitizing the image some form of degradation occurs at output. Improvement in quality of these degraded images can be achieved by using application of enhancement techniques The main purpose of image enhancement is to bring out details that are hidden in an image, or to increase the contrast in a low contrast image. Image enhancement produces an output image that subjectively looks better than the original image by changing the pixel's intensity of the input image. Generally, image enhancement enlarges the intensity differences among objects and background. There are many image enhancement techniques that have been proposed and developed [1]. In this paper, some image enhancement techniques have been discussed with their mathematical understanding [3]. This paper will provide an overview of underlying concepts with focus on spatial domain techniques and spatial filtering.

2. IMAGE ENHANCEMENT TECHNIQUE

2.1 Contrast Stretching

Contrast stretching enhances image by enhancing contrast between various parts of the original image. The basic idea is to improve the image quality by increasing the dynamic range of gray levels [4] (see graph in figure 1). A typical change in contrast enhancement, can be seen from the Figure 1.

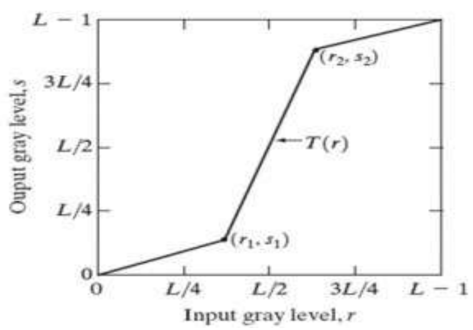

Figure 1: Shows the result of contrast stretching obtained using a simulation tool MATLAB.

2.2 Grey Level Slicing

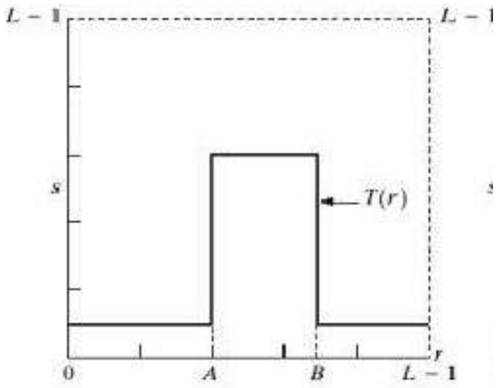

Figure 2: Grey Level slicing

A grey level slicing technique enhances all the gray levels in the range of interest using high values and all other gray levels using low values (Figure 2). This function is particularly useful to enhance flaws in X-ray images and enhancing features such as masses of water in satellite imagery. Figure 2 shows the transformation function for the range of pixels of interest and also showing the effect on image.

2.3 Histogram Processing

The histogram of a digital image with intensity levels in the range [0, L-1] is a discrete function

$$h(r_k) = n_k$$

k^{th} intensity value — Number of pixels in the image with intensity r_k

Histograms are frequently normalized by the total number of pixels in the image. Assuming an M x N image, a normalized histogram.

$$p(r_k) = \frac{n_k}{MN}, \quad k = 0,1,\ldots L-1$$

is related to probability of occurrence of rk in the image.[2].

2.3.1 Histogram Equalization (HE)

Histogram equalization is a technique by which the dynamic range of the histogram of an image is increased. It flattens and stretches the dynamic range of the image's histogram and resulting in overall contrast improvement [7]. Histogram equalization assigns the intensity values of pixels in the input image such that the output image contains a uniform distribution of intensities. It improves contrast by obtaining a uniform histogram (Figure 3). This technique can be used on a whole image or just on a part of an image [5].

2.3.2 Local Enhancement Equalization (LHE) technique

The Histogram Equalization discussed above is global method, which means it increases the overall contrast of the image. So this method is suitable for overall enhancement. This method can be easily adapted to local enhancement. The procedure is to define the neighbourhood and move the centre of this area from pixel to pixel. At each location, calculate histogram of the points in the neighbourhood. Obtain histogram equalization/specification function. Finally this function is used to map gray level of pixel cantered in neighbourhood [6]. It can use new pixel values and previous histogram to calculate next histogram [3].

2.4 Image Subtraction

This technique vital role in medical applications. The most important application is mask mode radiography. The primary use of image subtraction includes background removal and illumination equalization. The image difference between two images f(x,y) and g(x,y) can be expressed as

$$Z(x,y)=f(x,y)-g(x,y)$$

By analyzing the image obtained by subtraction, the doctor is in a position to decide the actual location of blood blockage [6].

3. SPATIAL FILTERING

The purpose of these filters is to remove unwanted noise from the image. It is one of principle tools used in this field for broad spectrum of applications[2].Spatial filters can be broadly classified into two types:

1 Smoothing Spatial Filters
2 Sharpening Spatial Filters

3.1Smoothing Filters

They are used for blurring and for noise reduction. They replaces each pixel by the average of pixels contained in the neighbourhood (filter mask). They are also called averaging or low-pass filters. It reduces the noise such as bridging of small gaps in the lines or curves in the image [6].

Original image **Enhanced Image**

Figure 3. Enhancement by Linear smoothing filter

There response is based on ordering the pixels contained in the image area encompassed by the filter, and then replacing the centre with the value determined by the ranking result[2].The well known median filter is a Non-Linear filter.

Original image **Enhanced Image**

Figure 4. Enhancement by Median Filter

3.2 Sharpening Spatial Filters

The principle objective of sharpening is to highlight transitions in intensity.Its applications ranging from electronic printing and medical imaging to industrial inspection[2]. It can provide more visible details that are poor, hazy and of obscured focus in the original image[6]. The well known sharpening filter is High pass filter.

Original image **Enhanced Image**

Figure 5. Enhancement by Highpass filter

4 EXPERIMENTAL RESULTS

The comparison is made between various spatial domain techniques by implementing these methods in Matlab (7.0.2). The quantitative metrics used for comparison are SNR, PSNR [8-11].

Signal-to-Noise Ratio(SNR) =

$$\frac{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\hat{f}(x,y)^2}{\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[f(x,y)-\hat{f}(x,y)]^2}$$

Here, $\hat{f}$ is the enhanced image and f is the original image [8] and higher value of SNR indicates good quality.

Peak Signal-to-Noise Ratio(PSNR) =

$$10log_{10}(\frac{R^2}{MSE})$$

The PSNR computes the peak signal-to-noise ratio, in decibels, between two images. This ratio is often used as a quality measurement between the original and an enhanced image. The higher the PSNR, the better the quality of the enhanced image. The results of the analysed methods are shown in Table 1. From the numerical values, it was concluded that contrast stretching yields higher values of the metrics.

By visual inspection of output images (enhanced) (Figure 6) of different methods, one can easily determine the difference between the input image and the enhanced image.

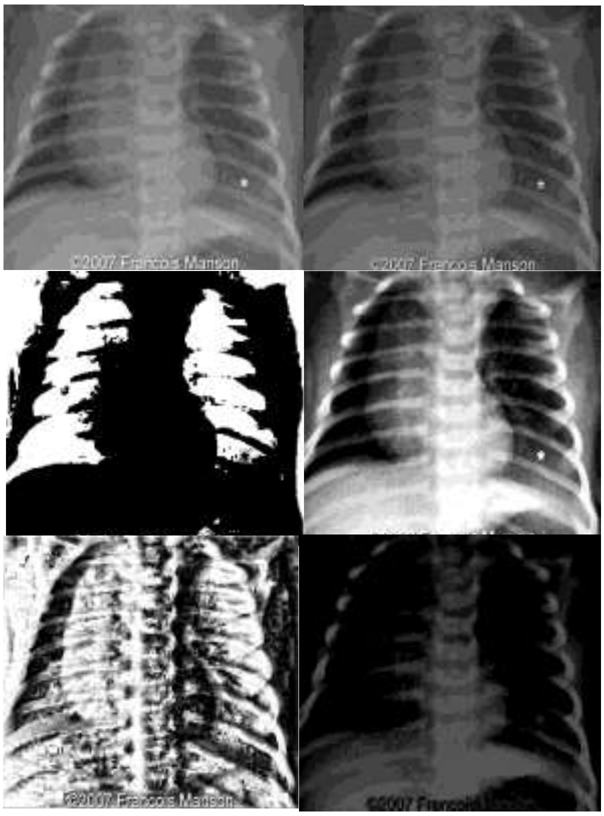

Figure 6:(a) Original image. (b) Image after Contrast Stretching. (c) Image after gray level slicing. (d) Image after Histogram Equalization. (e) Image after Local Histogram Equalization. (f) Image after Image Subtraction method.

Table1: Comparison of various methods

Parameters→	**SNR**	**PSNR**
Contrast Stretching	8.8708	18.0356
Gray level Slicing	-0.4424	4.9978
Histogram Equalization	9.5603	14.2634
Local Enhancement	5.7577	9.4291
Image Subtraction	-8.4707	7.2335

5. CONCLUSION

In this paper, various techniques of enhancement are implemented and compared. From the experimental results, it is found that contrast stretching yields best among the methods under study. In future, for the enhancement purpose more images can be taken from the different application fields so that it becomes clearer that for which application which particular technique is better.

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