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Review and Analysis of Image Enhancement Techniques

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Abstract

Image enhancement is one of the challenging issues in image processing. The objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a lots 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 will provide an overview and analysis of different techniques commonly used for image enhancement and presented which technique is used under which conditions

Keywords— Digital Image Processing, , Histogram Equalization, Image Enhancement.

1.Introduction

Digital image processing is a broad subject and often involves procedures which can be mathematically complex, but central idea behind digital image processing is quite simple[1]. The ultimate aim of image processing is to use data contained in the image to enable the system to understand, recognize and interpret the processed information available from the image pattern.. Generally image enhancement techniques are used to get detail that is obscured, or to highlight certain features of interest in image. In image enhancement process one or more attributes of image are modified. Image enhancement can be applied to different areas of science and engineering. Except for illumination conditions, quality of images is also affected by external noises and environmental disturbances such as ambient pressure and temperature fluctuations. Thus, image enhancement is necessary. Image enhancement (IE) has contributed to research advancement in a variety of fields. Approaches of contrast limited image enhancement via stretching the histograms over a reasonable dynamic range and multi-scale adaptive histogram equalizations can be developed. An adaptive algorithm is adapted to the image intensity distribution either globally or locally. By separating smooth and detail areas of an image, the algorithm is applied to each of them to avoid excessive enhancement of noises. In most cases, quality of images is affected by atmosphere medium and water medium, therefore image enhancement is required.

ii.AREAS IN WHICH IMAGE ENCHANCEMENT USED

Some of the areas in which IE has wide application are noted below [2].

1. In atmospheric sciences, image enhancement is used to reduce the effects of haze, fog, and turbulent weather for meteorological observations. Image enhancement helps in detecting shape and structure of remote objects in environment sensing. Satellite images undergo image restoration and enhancement to remove noise.
2. In forensics, Image enhancement is used for identification, evidence gathering and surveillance. Images obtained from fingerprint detection, security videos analysis and crime scene investigations are enhanced to used in identification of culprits and protection of victims.
3. Astrophotography faces challenges due to light and noise pollution that can be minimized by IE. For real time sharpening and contrast enhancement several cameras have in-built IE functions. however, numerous software, allow editing such images to provide better results.
4. In oceanography the study of images reveals interesting features of water flow, sediment concentration, geomorphology and bathymetric patterns to name a few. These features are more clearly observable in images that are digitally enhanced to overcome the problem of moving targets, deficiency of light and obscure surroundings.

Numerous other fields including law enforcement, microbiology, biomedicine, bacteriology, etc., benefit from various IE techniques. These benefits are not limited to professional studies and businesses but extend to the common users who employ IE to cosmetically enhance and correct their images.

iii.image enhancement techniques

Various techniques are used for image enhancement which are given below.

A. Histogram equalization

Histogram equalization [3] is a very common technique for enhancing the images. Suppose we have an image which is predominantly dark. Then its histogram would be skewed towards the lower end of the grey scale and all the image detail is compressed into the dark end of the histogram.If it could `stretch out' the grey levels at the dark end to produce a more uniformly distributed histogram then the image would become much clearer. Histogram equalization stretches the histogram across the entire spectrum of pixels (0 – 255). It increases the contrast of images for the finality of human inspection and can be applied to normalize illumination variations in image understanding problems[3]. Histogram equalization is one of the operations that can be applied to obtain new images based on histogram specification or modification. Histogram equalization is considered a global technique. This process is quite simple and for each brightness level j in the original image, the new pixel level value (k) is calculated as given in equation 3.1.

$$K = \sum_{i=0}^{j} \frac{N_i}{T} \quad (3.1)$$

Where the sum counts the number of pixels in the image with brightness equal to or less than j, and T is the total number of pixels.The main purpose of histogram equalization is to find gray level transformation function T to transform image f such that the histogram of T(f) is equalized.

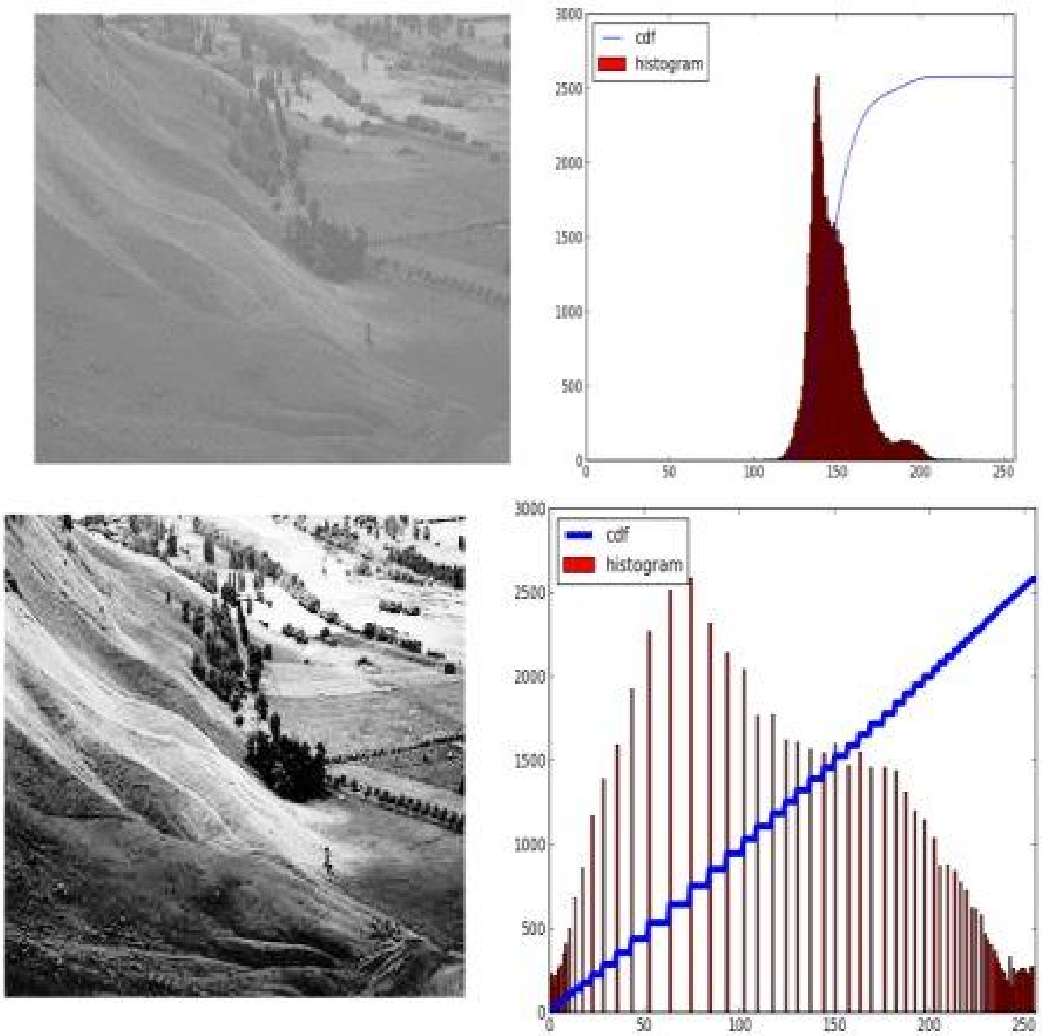


Figure 1. The original image and its histogram

B. Local Enhancement

Previous methods of histogram equalizations and histogram matching are global. So, local enhancement [4] is used. Define square or rectangular neighborhood (mask) and move the center from pixel to pixel. For each neighborhood, calculate histogram of the points n the neighborhood obtain histogram equalization /specification function. Map gray level of pixel centered in neighborhood. It can use new pixel values and previous histogram to calculate next histogram.

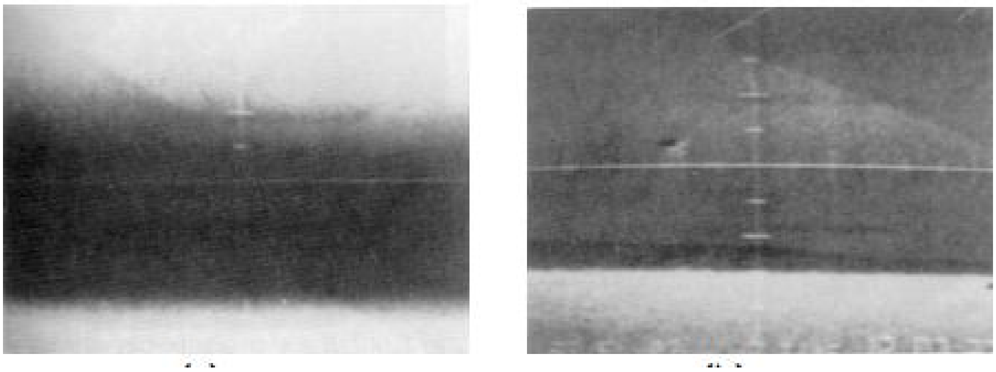


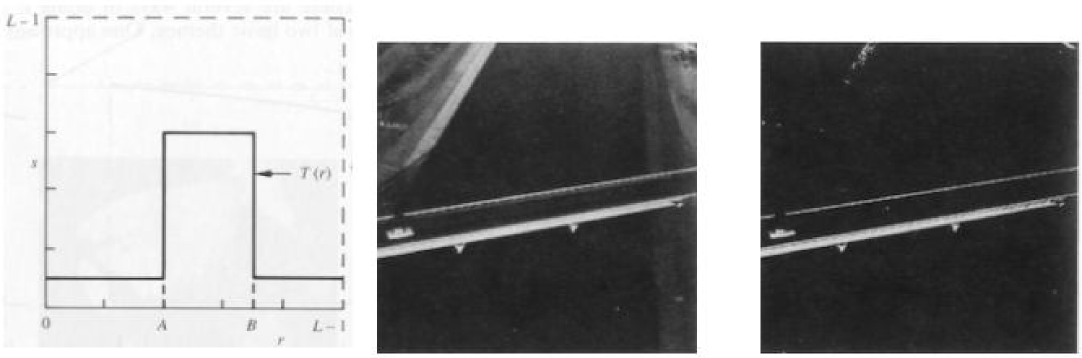
Figure 2. (A) Original Image (b) Result of Local histogram

C. Log Transformations

The log transformation maps [5] a narrow range of low input grey level values into a wider range of output values.The inverse log transformation performs the opposite transformation. Log functions are particularly useful when the input grey level values may have an extremely large range of values.Sometimes the dynamic range of a processed image far exceeds the capability of the display device, in this case only the brightest parts of the images are visible on the display screen. To solve this problem an effective way to compress the dynamic range of pixel values is to use the Log Transformations, which is given by,

$$g(x, y) = c. \text{Log}\ (1 + r)) \ldots\ldots\ldots\ldots\ldots \quad (3.2)$$

Where c is constant and it is assumed that $r \geq 0$.This transformation maps a narrow range of low-level grey scale intensities into a wider range of output values. Log Transformations is used to expand values of dark pixels and compress values of bright pixels[9]. Inverse log transform function is used to expand the values of high pixels in an image while compressing the darker-level values.Inverse log transform function maps the wide range of high-level grey scale intensities into a narrow range of high level output values. Example of log transformation is given below.



(a) (b) (c)

Figure 3. Example showing effect of Logarithmic transformation (a) Tranfer Function (b) Original Image (c) Processing Output

D. Thresholding Transformations

Thresholding transformations [6] are particularly useful for segmentation in which we want to isolate an object of interest from a background. Image threshold is the process of separating the information (objects) of an image from its background, hence, thresholding is usually applied to grey-level or color document scanned images.Thresholding can be categorized into two main categories:global and local. Global thresholding methods choose one threshold value for the entire document image, which is often based on the estimation of the background level from the intensity histogram of the image; hence, it is considered a point processing operation. Global thresholding methods are used to automatically reduce a grey-level image to a binary image. The images applied to such methods are assumed to have two classes of pixels (foreground and background). The purpose of a global thresholding method is to automatically specify a threshold value T, where the pixel values below it are considered foreground and the values above are background. A simple method would be to choose the mean or median value of all the pixels in the input image, the mean or median will work well as the threshold, however, this will generally not be the case especially if the pixels are not uniformly distributed in an image.

Local adaptive thresholding uses different values for each pixel according to the local area information. Local thresholding techniques are used with document images having non-uniform background illumination or complex backgrounds, such as watermarks found in security documents if the global thresholding methods fail to separate the foreground from the background[6]. This is due to the fact that the histogram of such images provides more than two peaks making it difficult for a global thresholding technique to separate the objects from the background, thus; local thresholding methods are the solution.

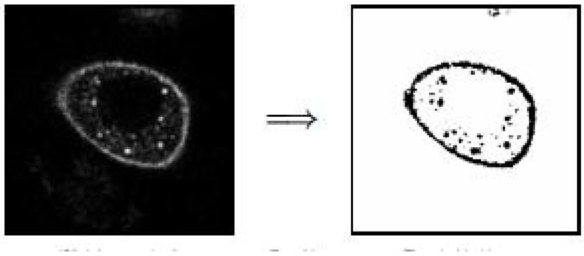


Figure 4. (a) Original Image (b) Result of Thresholding

E. Contrast Stretching

To expand the range of brightness values in an image the contrast enhancement techniques are used, so that the image can be efficiently displayed in a manner desired by the analyst. The level of contrast in an image may vary due to poor illumination or improper setting in the acquisition sensor device. Therefore, there is a need to manipulate the contrast of an image in order to compensate for difficulties in image acquisition[7]. The idea behind contrast stretching is to increase the dynamic range of the gray levels in the image being processed. The idea is to modify the dynamic range of the grey-levels in the images. Linear Contrast Stretch is the simplest contrast stretch algorithm that stretches the pixel values of a low-contrast image or high-contrast image by extending the dynamic range acros the whole image spectrum from 0 – (L-1).

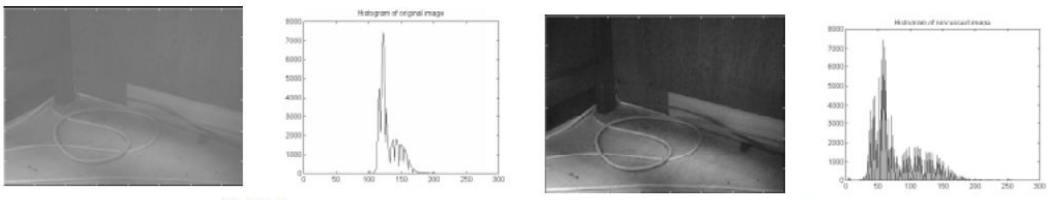


Figure 5. (a) Original Image (b) Result of Contrast Stretching

F. Un-sharp Masking

In the un-sharp masking (UM) approach[8] for image enhancement, a fraction of the high-pass filtered image is added to the original one to form the enhanced image [20].The input/output relation for the un-sharp masking filter can be written as follows:

$$x' = x + \lambda z \ldots\ldots\ldots\ldots \quad (3.3)$$

Where are the inputs, output images and is a positive constant which controls the fraction of the high-pass filtered image z to be added to the input image.

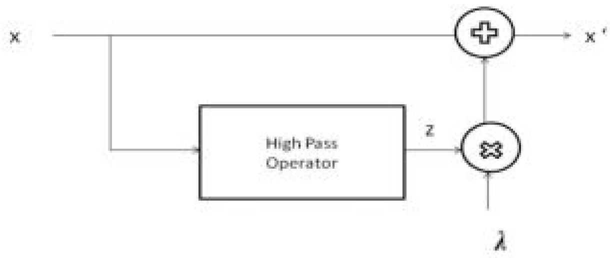


Fig. The un-sharp masking structure.

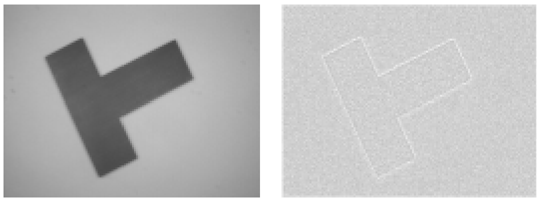


Figure 6. (a) Original Image (b) Result of Un-sharp Mask

This is a simple method, but it has two major drawbacks. First it enhances the noise present in the image. Second, it enhances too much the sharp transitions which lead to excessive overshoot on sharp edges.Below given table represents the comparative analysis of image enhancement techniques.

TABLE I. COMPARATIVE ANALYSIS OF IMAGE ENHANCEMENT TECHNIQUES

S.NO	TECHNIQUES	ADVANTAGES
1	Histogram Technique	This technique is very simple. Only the global histogram equalization can be done completely automatically.
2	Local Enhancement	This technique is very simple to use. In this technique we define a define square or rectangular neighborhood and move the center from pixel to pixel.
3	Log Transformation	Log Transformation is Useful for enhancing details in the darker regions of the image at the expense of detail in the brighter regions the higher-level values.
4	Thresholding transformations	Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background.
5	Linear Contrast Stretch	Linear Contrast Stretch is the simplest contrast stretch algorithm that stretches the pixel values of a low-contrast image or high-contrast image by extending the dynamic range acros the whole image spectrum

6	Un-sharp Masking	This is a simple method. In this technique, a fraction of the high-pass filtered image is added to the original one to form the enhanced image. It has two major drawbacks. First it enhances the noise present in the image. Second, it enhances too much the sharp transitions which lead to excessive overshoot on sharp edges.

iv.CONCLUSIONS AND FUTURE WORK

This paper survey some of the areas where image enhancement is done. This paper presents the most important techniques for image enhancement in digital image processing for grey scale images. Above table shows that different techniques and their advantages.Although this paper did not discuss the computational cost of enhancement techniques it may play a critical role in choosing an technique for real-time applications. Despite the effectiveness of each of these algorithms when applied separately, in practice one has to devise a combination of such methods to achieve more effective image enhancement.

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