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A Review on 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 lot of choices for improving the visual quality of images. Appropriate choice of such techniques is very important. This paper will provide an overview and analysis of different techniques commonly used for image enhancement. Image enhancement plays a fundamental role in vision applications. Recently much work is completed in the field of images enhancement. Many techniques have previously been proposed up to now for enhancing the digital images. In this paper, a survey on various image enhancement techniques has been done.**

Keywords-component; Digital Image Processing, Histogram Equalization, Image Enhancement.

I. INTRODUCTION

Various kinds of image and pictures are used as the source of information in present day applications and communication system. whenever an image is taken some of the degradation may occur like blurred image. Also, when an image is converted from one form to another form such as scanning, transmitting, storing etc., some of the degradation occurs at the output. Hence the output image must need to improve for the batter visual appearance of an image. Image denoising, enhancement and sharpening are important operations in the general fields of image processing and computer vision. Enhancement of noisy image is a very challenging task in many research and application area. There is a collection of techniques to improve the visual appearance of an image, like image enhancement, image deblurring, image sharpening, image smoothing, image filtering and various noise removing techniques.

Image enhancement process consist to improve the appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. Enhancement of image is very challenging issue in many research and application areas. Image enhancement techniques are used to improve certain features by modifying the colors or intensities. Technique applied for enhancing is applicable for medical image processing and image processing application areas like satellite image processing, biometric image processing etc.

II. IMAGE ENHANCEMENT TECHNIQUES

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

A. Histogram equalization

Histogram equalization 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. 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.

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

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.

B. Adaptive histogram equalization

Histogram equalization expand active range of strength value while squash the histogram. On many images, histogram equalization provides suitable results, but suitable to its global

treatment of the image, sometimes it more than enhance the image. It's used to enhance difference in images. Histogram equalization highlight only on local compare place of overall compare. Adaptive histogram equalization overcomes from this topic, this technique appropriate for general techniques. Once the image contain region that are expansively lighter and dark, the contrast in those regions will not be sufficiently enhanced. So adaptive histogram equalization compute correctly image region. Adaptive histogram equalization enhances the contrast of images by transform the values in the intensity image. The contrast transform meaning is calculating for each of these regions independently. The optimal size of region depends on the type of the input image, and it is superlative determined during experimentation.

C. *Fuzzy Logic Technique*

Fuzzy-logic has been efficiently found in different elements of image processing. Recently fuzzy based algorithms for image enhancement have been developed with better performance com-pared to conventional and other advanced techniques like GLG. Fuzzy image processing includes mainly three stages: image fuzzification, modification of membership values, and, if necessary, image DE fuzzification. After the image data are transformed from gray-level domain to the fuzzy membership domain (fuzzification), appropriate fuzzy techniques modify the membership values.

Figure 1. The main principle of Fuzzy Image enhancement

D. *Nuro Fuzzy System*

Neuro-fuzzy systems are the Artificial Neural Network (ANN) based fuzzy systems. ANN determines the properties of data samples by processing it. Predictive power of ANN is more than that of signal analysis techniques. Fuzzy set theory is essential, for dealing with uncertainty. Neuro-Fuzzy system is a system where the fuzzy rules and sets are adjusted using neural network techniques in iterative manner with the set of pair of input and output data vectors. First such system behaves like a neural network where learning of parameters occurs and at the time of execution it behaves like a fuzzy.

Neural network will detect types of noise whether it is salt and pepper, gaussian and non-gaussian noise. And then Fuzzy logic will apply proper filter based on type of noise.

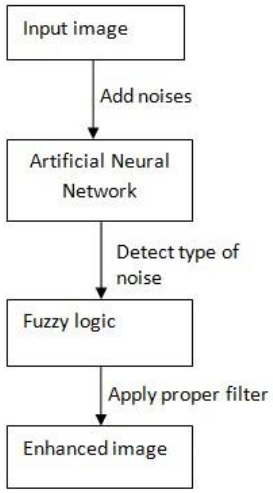

Figure 2. The principle of Nuro-Fuzzy Image enhancement

E. *Unsharp Masking*

In the un-sharp masking (UM) approach for image enhancement, a fraction of the high-pass filtered image is added to the original one to form the enhanced image. In this method, un-sharp masking is applied in partial way for detection of the edges and boundary lines in the image and then a conservative smoothing operation is applied on the selected areas to remove undesirable edges which represents the salt and pepper noise. Finally, the noise free edge image is added with the smoothed image to get the original image with reduced noise. The input/output relation for the un-sharp masking filter can be written as follows:

$$\bar{x} = x + \lambda z \quad \ldots\ldots\ldots\ldots$$

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.

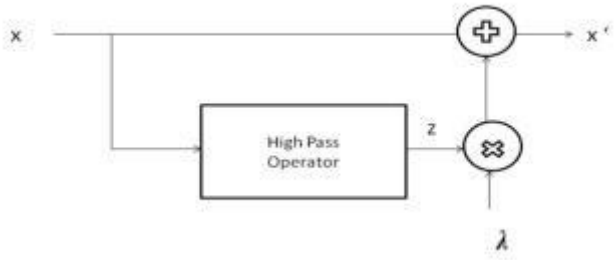

Figure 3. The un-sharp masking structure

F. *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 to compensate for difficulties in image acquisition. 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 across the whole image spectrum from 0 – (L-1).

G. Thresholding Transformations

Thresholding transformations 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 is 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. 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.

H. Log Transformations

The log transformation maps 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. 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.

I. Log Transformations

Previous methods of histogram equalizations and histogram matching are global. So, local enhancement 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 obtains 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.

TABLE I. COMPARATIVE ANALYSIS OF IMAGE ENHANCEMENT TECHNIQUES

S.N.	TECHNIQUES	ADVANTAGES
1	Histogram equalization	This technique is very simple. Only the global histogram equalization can be done completely automatically.
2	Adaptive Histogram equalization	This method has advantage of being quick making it simple based on transform adaptive histogram. The results of this technique shows outperform from commonly used enhancement technique like histogram equalization.
3	Fuzzy Logic Technique	The fuzzy rule-based approach is a powerful method for formulation of expert system in a comprehensive way. Fuzzy logic represents the good mathematical frame works to deal with uncertainty of information.
4	Nuro Fuzzy System	The neural networks used for identification of noise using the statistical parameters whereas fuzzy logic is used for enhancement purpose. The system behaves like a neural network where learning of parameters occurs and at the time of execution it behaves like a fuzzy.
5	Unsharp Masking	This is the simple technique. 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.
6	Contrast Stretching	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
7	Thresholding transformations	Thresholding transformations are particularly useful for segmentation in which we want to isolate an object of interest from a background.
8	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.
9	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.

III. Conclusion And Future Work

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

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