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A CRITICAL OVERVIEW OF VARIOUS IMAGE ENHANCEMENT TECHNIQUES

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ABSTRACT-

Image Enhancement is one of the popular techniques for improving the visual quality of images. Image Enhancement provides processing of poor images which helps extracting the information from selected images. The principle objective of image enhancement is to modify image to make it more suitable for specific application. In this paper image enhancement techniques are discussed with their mathematical understanding. This paper will provide an overview different image enhancement technique along with algorithms used for image enhancement. The paper focuses on point and spatial operation technique for image enhancement.

KEYWORDS- Image Enhancement, Point Operation, Spatial Operation Technique.

1. INTRODUCTION

Image Enhancement is one of the widely used techniques used in digital image processing. Image enhancement improves the perception of information in images for human viewers and providing better processed image. It helps in maximising clarity, sharpness of selected images [1]. Digital Image Processing refers as processing of any two-dimensional pictures (digital image) by a digital computer. A digital image is an array of real or complex numbers represented by a finite number of bits. The sources of images range from scanning micro-densitometer to high-resolution video camera, airborne solid-state camera and commercial earth resources satellites [2].

In this paper basic image enhancement techniques used for digital image processing have been discussed. Image enhancement technique can be classified in two types i.e. point operations and spatial operation technique. The point processing technique can be explain using different transformation i.e. contrast stretching transformation, thresholding transformation, digital negative transformation and histogram equalization whereas spatial processing technique uses filtering techniques like spatial & smoothing filter [3]. This paper will provide an overview of above image enhancement techniques. The goal of image enhancement technique is to accentuate certain image features for a specific application.

2. POINT OPERATION TECHNIQUE

Point operation technique is a technique in which processing of algorithms to enhance the each pixel separately. Point transformations are represented by expression,

$$v=f(u) \qquad (1)$$

where u is the input image, v is the processed image, and $f(u)$ is an operator that operate only at the pixel. There are many different point operation transformation methods are used to improve images in some sense [4].

2.1 CONTRAST STRETCHING TRANSFORMATION

The low contrast image acquired by imaging sensor is due to poor or non uniform lighting condition or due to nonlinearity. Using contrast stretching the range of brightness values in an image extend, so that the image can be efficiently displayed in a manner. The contrast stretching transformation can be expressed as,

$$\begin{aligned} v&=\alpha\, u && 0 \le u < a \\ v&=\beta\,(u-a)+v_a && a \le u < b \\ v&=\gamma\,(u-b)+v_b && b \le u < L \end{aligned} \qquad (1)$$

The slope of the transformation is chosen greater than unity in the stretch region. For dark region

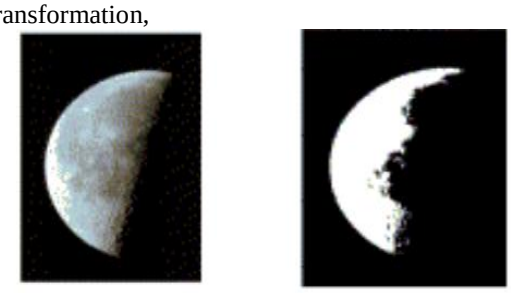
stretch α > 1, for midregion stretch β > 1 and γ > 1 for bright stretch [1][5]. The following figure shows example of contrast stretched image,

(a) *(b)*

Fig. 1 *(a) Gray Scale Image (b) Contrast Stretch of Gray Scale Image*

2.2 THRESHOLDING TRANSFORMATION

Thresholding transformation is one the technique useful in image segmentation in which the object of interest is isolated from background. Thresholding is usually applied to grey-level or color document scanned images [4][5]. The following figure shows image of moon and thresholded image after applying thresholding transformation,



(a) *(b)*

Fig. 2 *(a) Original image of moon (b)Thresholded image*

2.3 DIGITAL NEGATIVE TRANSFORMATION

One of the simplest methods of point processing is to compute the negative of image. In this transformation the pixel gray value of image is inverted. Suppose the image *u* having gray level or intensity level in the range *[0, L-1]*, the processed negative image *v* can be as follow,

$$v = u - L \qquad (1)$$

Negative images are useful for enhancing white or gray detail from dark region of an image. The digital negative transformation is effectively used in medical image processing [3][5]. The following figure shows the digital negative of image,

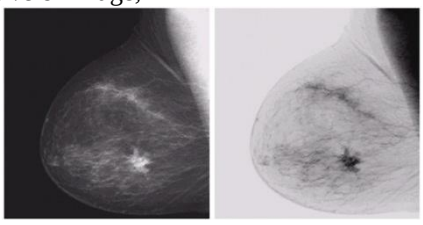


Fig. 3 *Negative image of Mammogram*

2.4 HISTOGRAM MODELING

Histogram modeling is one of popular technique of point processing technique of image enhancement. The histogram of an image represents frequency of appearances of different gray level contained in the image. The image can be modifying by using histogram modeling so that its histogram has a desired shape.

The histogram of image is graphical representation of the gray values in a digital image. The histogram of a digital image with intensity levels in the range *[0, L – 1]* is a discrete function can written as,

$$h(r_k) = n_k \qquad (1)$$

where r_k is the k^{th} intensity value i.e. *k=0,1,2,.....L-1*, n_k is the number of pixels in the image with intensity of r_k.

2.4.1 HISTOGRAM EQUALIZATION

Histogram Equalization is widely used to enhance the contrast of the image. The histogram of bad images is usually narrow while that of good images are wide. Using histogram equalization the histogram of bad image is modified. In this technique extra pixels is added to the light regions of the image and removes extra pixels from dark region of the image resulting in a high dynamic range in the output image.

The histogram equalization technique changes the PDF (Probability Density Function) of given image into that of uniform pdf that spreads pixel value from 0 to L-1.

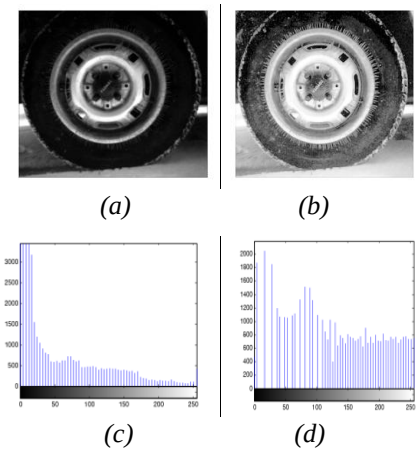
The pdf of image x can be calculated as,

$$pdf(x) = p(r_k) \qquad (1)$$

From the pdf we can obtain the cdf as follows,

$$cdf(x) = \sum_{k=0}^{L-1} p(r_k) \qquad (2)$$

Thus the histogram equalization operation is then equal to cdf [6]. The following figure shows effect of histogram equalization on image.



(a) *(b)*

(c) *(d)*

Fig. 4*(a) Original Image (b) Enhanced image (c) Histogram of Original Image (d) Histogram of Equalized image.*

The fig. 3 (c) shows histogram of original image as shown in fig. 3 (a), after applying histogram equalization the equalized image is shown in fig. 3 (b) with its histogram i.e. in fig. 3 (d), which shows the pixels in the image have a wide histogram representation indicating that the image is of a high quality.

3. SPATIAL OPERATION TECHNIQUE

In Image Enhancement many techniques are based on spatial operations performed on local neighbourhood of input pixels. In spatial processing filtering techniques are used like spatial and smoothing filter which is further classified whether it is linear or non linear.

SPATIAL FILTERS

Spatial filter refers to an image operators that change the gray value at any pixel (x,y) depending on the pixel value in a square neighborhood centred at (x,y) using a fixed integer matrix of the same size. Filtering creates a new pixel with coordinates equal to the coordinates of the centre of the neighbourhood and whose value is the result of the filtering operation. The mechanism of special filtering consists simply of moving the filter mask from pixel to pixel in an image. At each pixel (x,y), the response of the filter at that pixel is calculated using a predefined relationship i.e. linear or nonlinear [7]. The following figure shows basic spatial filter mask.

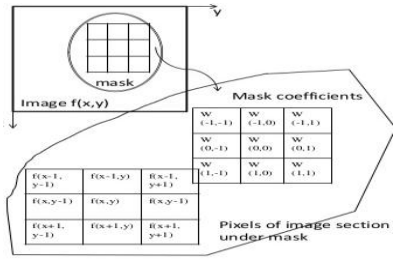


Fig. 5 *Spatial Filtering*

3.1.1 LINEAR SPATIAL FILTER

The linear spatial filter consists of moving the filter mask from pixel to pixel in an image. In general, filtering of image f of size MxN with a filter mask of size mxn is given by expression,

$$g(x,y) = \sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)\, f(x+s, y+t) \qquad (1)$$

where a=(m-1)/2 and b=(n-1)/2. To generate a complete filtered image, this equation must be applied for x=0,1,2,....M-1 and y=0,1,2,.....N-1.

3.1.2 NON LINEAR SPATIAL FILTER

In non linear filter operation also consists of moving the filter mask from pixel to pixel in an image. The filtering operation is based conditionally on the values of the pixels in the neighborhood, and they do not explicitly use coefficients in the sum of products manner. In non linear filter noise reduction can be achieved effectively whose basic function is to compute the median gray-level value in the neighbourhood.

3.2 SPATIAL SMOOTHING FILTERS

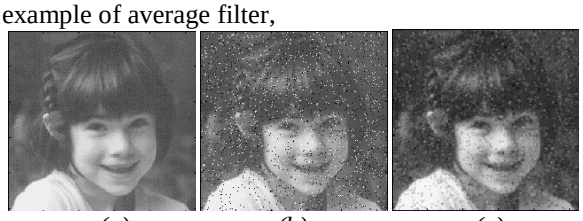
Spatial smoothing filters are used for blurring and noise reduction. Blurring is used preprocessing tasks such as removal of small details from a large image for object extraction. Noise reduction can be accomplished by blurring with a linear filter and also by nonlinear filtering [8].

3.2.1 Linear Smoothing Filters

The output response of linear smoothing filter is simply the average of the pixels contained in the neighborhood of the filter mask. These filters sometimes are called averaging filters. They are also referred to as low pass filters. Noise and edges consist of sharp transitions in gray-levels therefore linear smoothing filters are used for noise reduction. In averaging filtering an image of size MxN with a filter mask of size mxn is given by the expression,

$$g(x,y) = \frac{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)\, f(x+s, y+t)}{\sum_{s=-a}^{a}\sum_{t=-b}^{b} w(s,t)} \qquad (1)$$

To generate a complete filtered image, this equation must be applied for x = 0, 1, 2, ...M-1 and y=0, 1, 2, ….N-1 [7][9]. The denominator in the above equation is simply the sum of the mask coefficients. Hence it is a constant that needs to be computed only once. The following figure shows an example of average filter,



(a) *(b)* *(c)*

Fig. 6 *(a) Original Image (b) Noise Added Image (c) Average Filtered Image*

3.2.2 NON LINEAR SMOOTHING FILTERS

Non linear smoothing filters is an order-statistic filter whose response is based on ranking the pixels contained in the image area encompassed by the filter, and then replacing the value of the centre pixel with the value determined by the ranking result. The best known filter in this category is the median filter. Median filters are quite popular because, for certain types of random noise, they provide excellent noise reduction capabilities, with considerably less blurring than linear smoothing filters of similar size.

In this filtering the input pixel is replaced by the median of the pixels contained in a window around the pixel which can be given by,

$$v(m,n) = median\{y(m-k, n-l), (k,l) \varepsilon W\} \qquad (1)$$

where *W* is a suitably chosen window. The algorithm for median filtering requires arranging the pixel values in the increasing or decreasing order and picking the middle value. It is useful for removing isolated lines or pixels while preserving spatial resolution [10]. The following figure an example of median filter,

(a) *(b)* *(c)*

Fig. 7 *(a) Original Image (b) Noise Added Image (c) Median Filtered Image*

4.CONCLUDING REMARKS

Image Enhancement technique offer a wide variety of algorithms which approaches for modifying images to achieve visually acceptable image. The selection of such techniques is a function of the observer characteristics, image content, viewing conditions. The review of image enhancement techniques using point and spatial operation have been successfully accomplished with the results for each method. The point processing method is most primitive for image processing. Primarily using contrast stretching transformation the pixels occur most frequently stretched to improve the overall visibility of a gray scale image. Thresholding transformation is used to isolate the object of interest from background, digital negative transformation used for enhancing the white detail from medical images and histogram equalization stretches the contrast by redistributing the gray level values uniformly. The spatial processing technique used with reference to point processing method. Spatial operation carried out with spatial and smoothing filter which is used based on the type of image and type of noise with which it is corrupted; it is observed that non linear filter is better than linear filter. We show the existing technique of image enhancement and discuss the algorithms, it may play a critical role in choosing an real-time applications.

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