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Review of Image Enhancement Techniques for Digital Images

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Abstract— The main target of the image enhancement is to make the images more clearer so that they can be easily understood and can be easily interpreted. Moreover, image enhancement provides us the facility to gather a good stock of information from the image after enhancing it. The image enhancement techniques may have frequency domain and spatial domain. Further, types of spatial domain techniques are of many types that are explained in this paper. In this paper various image enhancement techniques have been reviewed. Image enhancement techniques are used to improve the virtualization of an image for various applications. Images can be enhanced by altering its features like contrast and resolution. In this paper, different image enhancement methods are highlighted.

Keywords— Image Enhancement, Images, Transformations, Filters

I. INTRODUCTION

Digital images consists of picture elements called pixels. Each pixel has its own color. Digital images are very effective in transmitting the information. But ordinarily these images are of low contrast or are noisy. This makes the image difficult to understand. Image enhancement difficulties can be formulated as if we have an input low quality image and the output high quality image for particular applications. As we all know that image enhancement has received much attention in medical imaging. So the main aim was to improve the appearance of image or give transform representations as segmentation, analysis, detection and recognition. There are several challenging areas where image enhancement carrying is difficult. From the darker background, we can't extract clearer objects due to low contrast. If the color and background are same then color based methods will not work.[1] Therefore, image enhancement techniques are required.

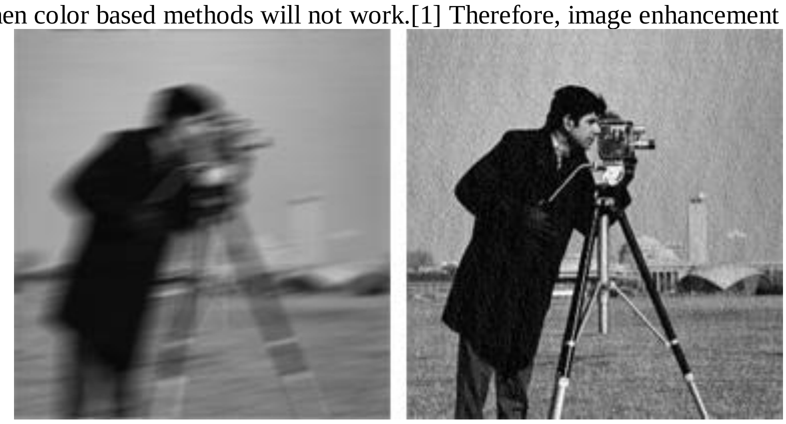

Fig. 1 Effect of Image Enhancement

Image enhancement means ascending the visualization of an image by ascending the dominance of some of it's features and descending the ambiguity between the different areas of an image. Image enhancement can be divided into two parts: spatial domain and frequency domain methods. In spatial domain method, picture elements of an image are directly worked upon or manipulated to get the actual wished results and in frequency domain method, the image is operated and Fourier transformation of the image is done.

II. IMAGE ENHANCEMENT

Image enhancement can be defined as perception of information for humans to get and provide good quality of input. It helps in modifying image attributes so that it becomes more suitable. While processing, more than one attributes can be modified. Rather these choice of attributes and how we modify are particular for a given task[2]. There are many techniques in order ta enhance an image. These methods can be classified as following in two categories:

1. Spatial Domain Methods
2. Frequency Domain Methods

In spatial domain, we deal with the image pixels. To achieve desired enhancement, pixel values are manipulated. In frequency domain, the image is first transferred in to frequency domain. It means that we compute fourier transform first.

III. IMAGE ENHANCEMENT TECHNIQUE

A. Spatial Domain Technique

This method is performed on the pixels of an image. The understandability of the data that is acquainted by the image can be increased by spatial domain technique. [3] Formula for this method is:

g(X,Y)=T[f(X,Y)]

where,

g (X, Y) ---> Output Image

f (X, Y) ---> Input Image And

'T' ---> transformation i.e; applied on an input image.

Further, Spatial domain technique is divided into sub-categories; explained below.

1) Gray Level Transformation :

This technique is processed when the neighborhood of the pixel is pixel itself.[4] For this, the equation will be as follows:

s = T(r)

where,

T ---> gray level transformation function.

Further, Gray level transformation method has following types:-

- **Image negative**

The negative of an image with grey levels in the range [0, L-1] is obtained by the negative transformation is given by expression,

s = L - 1 - r

The gray level intensities of a processing image can be reversed using the above expression and therefore producing the negative like image. By this, the white region is converted into black and vice-a-versa.[5]

- **Contrast Stretching**

In the processing image, using the contrast stretching technique the dynamic range of the gray levels can be emphasized. The most easiest contrast stretch algorithm is the linear contrast stretch by which the pixel values of the low contrast images can be stretched and by enlarging the dynamic range of a high contrast image over the whole image spectrum ranging from 0 to (L-1).[6] On the basis of the type of transformation, a pixel value 'r' is mapped into a pixel of value 's'.

2) Threshold Transformation :

Thresholding transformations are mostly effective for partitioning the image elements in which we wish to segregate a desired object from the background [7]. Image threshold transformation is an approach of segmenting the information from it's own background.. Therefore, thresholding is generally implemented on gray- level or scanned color document images.

If f(x,y) is the input image and g(x,y) is processed or output image then we can easily locate threshold image because it acquire pixel value of '0' or '1'.

3) Logarithmic Transformations :

Logarithmic transformations are widely utilized in the cases where the input values of gray level are very high [8]. These are used for spreading or compressing the grey levels in an image.

The general expression for Logarithmic transformation is:

S = C log (1+r)

where,

C ---> 1 or constant

r ---> >= 0

This transformation turns the input values of low range into the output values of higher range and vice -a- versa [7].

4) Power-Law Transformation :

The power Law transformation presents the relation between pixels of the input image f(x,y) and the boosted image g(x,y). General expression for this transformation is as :

s = crγ

In the above expression,

c and r ----> are positive constants,

By having 'c' = 1 and r with varying values the transformations can be achieved where 'r' results in ascending the contrast of some regions in the original image with high value in opposition of low regions. [9]

In Power Law Transformation each and every pixel value is upended to fixed power. This transformation technique is utilized for transfiguring small and dark range of input image elements (pixel) into larger and brighter range of output image elements (pixels) or vice-versa.

5) Histogram Processing :

Histogram processing is the vital method used in spatial domain method. It is generally utilized in reconstruction of real time images. [10] The gray level of range [0, L-1] in digital images is a discrete function,

H(rk)=nk

where,

rk ---> k is k^{th} gray level and

nk ---> no. Of pixels in the image with k^{th} gray level

6) Histogram Equalization :

Histogram equalization technique is the method employed to get uniform distribution of the picture elements (pixels) at all gray levels in the image [11]. Histogram of the dark image will be assembled near the lower gray level while the histogram of the bright image will be assembled near the higher gray level.

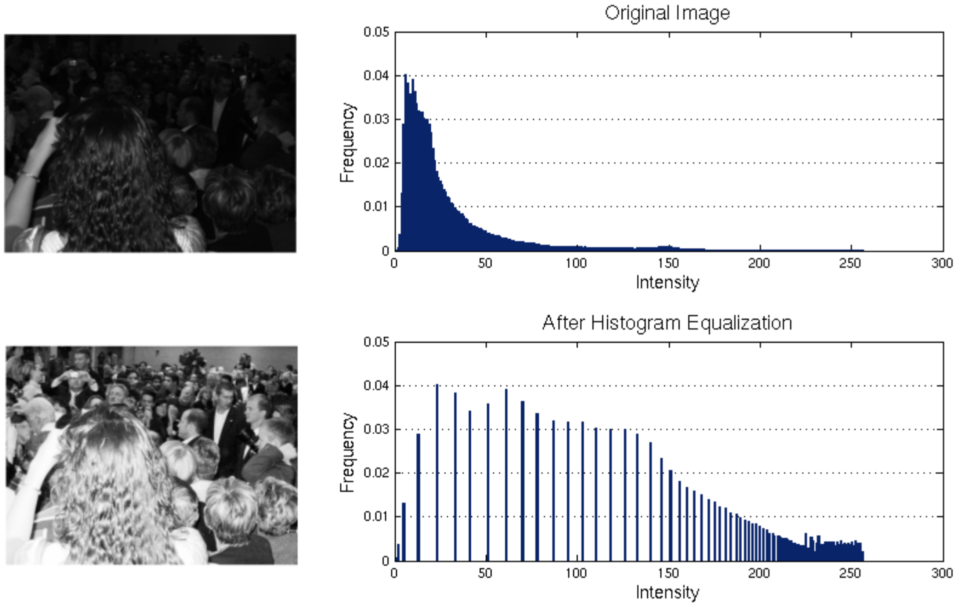

Fig. 2 Effect of histogram equalization

7) Spatial Filtering :

The word filter is gleaned from the frequency domain process and the filtering pertains to the filter frequency bands that is, receiving or denying frequencies [12]. Further, the filters are of two types that are: Low-pass filters : These are those filters that allows to pass low frequencies through them. These are used for blurring or smoothening the desired images and

High-pass filters: These are those filters that allows to pass high frequencies through them. Images can be directly smoothened by making the use of spatial masks.

Spatial filters can be categorized into two main types:

- Smoothing spatial filters
- Sharpening spatial filters

Both the types of the filters can be either linear or non-linear. In linear filters, each pixel value from an enhanced image is an average of the pixels in the neighborhood of the filter mask. The operations of the non-linear filter rely on pixel values in the neighborhood.

Smoothing Spatial Filters

It is basically used in reducing noise in an image. By using an averaging filter, average all of pixels in a neighbourhood around central value. The resulting image will have a reduced transitions in intensities such that we can achieve denoising. Thus weighted averaging filter reduced blurring in an image.

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

where $a=(m-1)/2$ and $b=(n-1)/2$

Sharpening Spatial Filters

To highlight the fine details or to enhance details of an image that has been blurred due to error or due to the process adopted for image acquisition. Sharpening of an image can be accomplished by spatial differentiation. [13]

The formula for the 1st derivative is: $\frac{\partial f}{\partial x} = f(x+1) - f(x)$

The formula for the 2nd derivative is:

$$\frac{\partial^2 f}{\partial^2 x} = f(x+1) + f(x-1) - 2f(x)$$

B. Frequency Domain Techniques

Rather than operating on the image itself the frequency domain methods are usually implemented for the manipulation of the orthogonal transform of the image rather than the image itself .According to the different frequency contents , different frequency domain techniques are applied for the processing of the image [14]. The core idea behind the frequency domain techniques for image enhancement is of computing a 2-Dimensional discrete unitary transform of an image, for example, the 2-Dimensional Discrete Fourier transform, by first altering the coefficients of the transform by M and then applying the inverse of the transform. The two main components of the orthogonal transform of an image are it's magnitude and it's phase. The magnitude is composed of the frequency content of an image whereas, the phase component is utilized to re-establish the image back to the spatial domain [15].

The combine formula for the transformation is as follows: [16]

G(u,v)=H(u,v) F(u,v)

Where,

G(u,v) ---> Enhanced image

H(u,v) ---> Transfer function

F(u,v) ---> Input image

The step by stepwise procedure for the above formula is:

I. An input image's preprocessing f(x,y)
II. Fourier transform of input image f(u,v)
III. Multiplying it by filter function H(u,v)
IV. Acquiring inverse Fourier transformation G(u,v)
V. Post processing and acquiring the enhanced image g(x,y).

IV. CONCLUSIONS

Ordinarily, the images are of low contrast or contains noise which makes the images difficult to understand and interpret. So, the image enhancement process is crucial for the digital images to make them better for understanding and interpretable.

In this paper, we have studied that the image enhancement techniques are divided into spatial domain and frequency domain. It is concluded that the frequency domain techniques are more advantageous than the spatial domain techniques. In this paper, we have gone through different image enhancement techniques but the more emphasis is given on spatial domain techniques. By applying all these above studied techniques, the original images are satisfactorily resulted into enhanced, reduced noise images and other hindrances are also removed from the original image. Using these techniques, the degradation can be eliminated from the image. Some practical applications of image negative are in medical images as it enhances white areas that are suppressed by black regions.

Although, all the algorithms and the techniques are very fruitful. Therefore, the technique/algorithm can be chosen according to the task and factors such as cost and output etc.

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