A Review of Image Enhancement Techniques

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Abstract: *Image Enhancement is one of the most important and difficult techniques in image research. The aim of image enhancement is to improve the visual appearance of an image, or to provide a better transform representation for future automated image processing. Many images like medical images, satellite images, aerial images and even real life photographs suffer from poor contrast and noise. It is necessary to enhance the contrast and remove the noise to increase image quality. One of the most important stages in medical images detection and analysis is Image Enhancement techniques which improves the quality (clarity) of images for human viewing, removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. The enhancement technique differs from one field to another according to its objective. The existing techniques of image enhancement can be classified into two categories: Spatial Domain and Frequency domain enhancement. Thus the contribution of this paper is to classify and review image enhancement processing techniques.*

Keywords: *Frequency Based Domain Enhancement, Histogram Equalization, Image Enhancement, Region Of Interest, Spatial Based Domain Enhancement.*

I. INTRODUCTION

Image enhancement improves the interpretability or perception of information in images. For automated image processing system it provides better input. It helps scrutinize background information that is essential to understand object behavior without requiring manual inspection. Due to low contrast image enhancement becomes challenging and also objects cannot be extracted clearly from dark background. Images with object and background having similar color fail here. The existing techniques of image enhancement can be classified into two types: Spatial based domain image enhancement and Frequency based domain image enhancement. Spatial based domain image enhancement act on pixels directly. Frequency based domain image enhancement is a term used to describe the analysis of mathematical functions or signals with respect to frequency and operate directly on the image - transform coefficients. Commonly used transform co-efficient are Fourier Transform (FT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT). The basic idea is to enhance the image by manipulating the transform coefficients. Spatial domain methods can again be divided into two sections: Point Processing operation and spatial filter operations. Traditional image enhancement method enhances low quality image where the back ground information are lost in the darker region. In this case whatever technique we apply, information cannot be retrieved from darker back ground. Image Smoothing, Image Sharpening, filtering are some of the commonly used frequency domain enhancement techniques. In this paper we focus on both spatial and frequency image enhancement techniques.

II. IMAGE ENHANCEMENT TECHNIQUES

Image enhancement techniques are used for enhancing the contrast of the image. These techniques are classified into two categories:

- Spatial Domain Enhancement
- Frequency Domain Enhancement

Spatial domain method directly deals with the pixel values of an image. Whereas Frequency domain method operates on Fourier transform of an image for enhancement of an image.

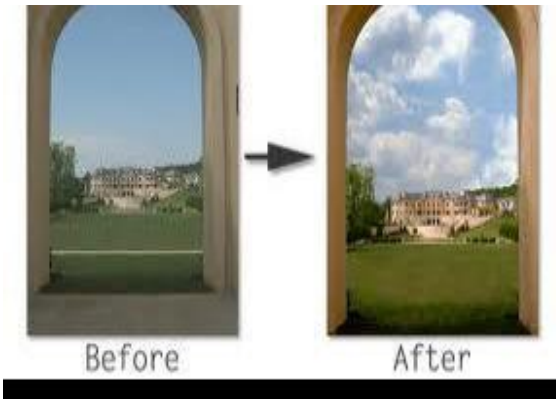

Figure 1: Showing The Effect Of Image Enhancement

III. SPATIAL DOMAIN ENHANCEMENT TECHNQUES

In spatial domain image enhance technique transformations are applied directly on the pixels. Point processing methods, log transformation, histogram processing, morphological operators are few spatial domain enhancement operations that are discussed below.

A. Gray Level Transformation

Gray level transformations are applied to improve the contrast of the image. This transformation can be achieved by adjusting the grey level and dynamic range of the image, which is the deviation between minimum and maximum pixel value.

B. Image Negative

Image negative, reverses the pixel value (i.e.,) each pixel is subtracted from L. Where, L is the maximum pixel value of the image. This can be expressed as

$$S=L-1-r$$

Where, s = negative image or output image.

$L-1$ = maximum pixel value r = input image. The pixel range for both the input image and negative image is (0, L-1).

C. Log Transformation

Log transformation [4] is used to expand the dark pixels and compress the brighter pixel. This compresses the dynamic range of the image with large variations in pixel values. Log transformation is given by

$$S=cLog(1+r)$$

D. Histogram Processing Histogram equalization

Histogram equalization is used for contrast adjustment using the image histogram When Region Of Interest(ROI) is represented by close contrast values, this histogram equalization enhances the image by increasing the global contrast. As a result, the intensities are well scattered on the histogram and low contrast region is converted to region with higher contrast. This is achieved by considering more frequently occurring intensity value and spreading it along the histogram. Histogram equalization plays a major role in images having both ROI and other region as either darker or brighter. Its advantage is, it goes

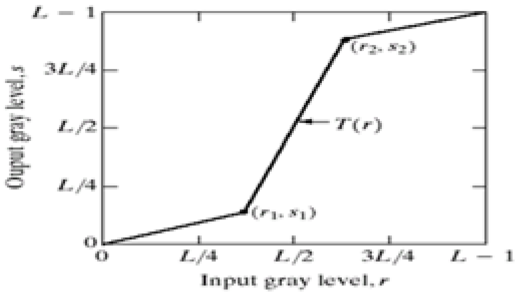

Figure 2: Contrast Stretching- Transformation Function

good with images having high color depth. For example images like 16-bit gray-scale images or continuous data. This technique is widely used in images that are over-exposed or under-exposed, scientific images like X-Ray images in medical diagnosis, remote sensing, and thermal images. Same way this technique has its own defects, like unrealistic illusions in photographs and undesirable effect in low color depth images.

E. Piecewise Linear Transformation Contrast Stretching

In contrast stretching, upper and lower threshold are fixed and the contrast is stretched between these thresholds. It is contrast enhancement method based on the intensity value as shown

$$I_0\ (x,y)=f(I(x,y))$$

Where, the original image is, the output image is after contrast enhancement, and the transformation function. The transformation function T(r) is given by (5), and shown in Fig-2.

$$T(r)=s.$$

Where, s= pixel value of input image F r = pixel value of output image G T = transformation function (H).

Where l, m, n are the Slopes of the three regions. It is obvious that l & n are < 1. The s is the modified gray levels and r is the original gray levels. Where a and b are the limit of lower and upper threshold. Contrast stretching makes brighter portion brighter and darker portion darker.

F. Morphological Operators Top-Hat Transformation:

Small elements or ROI or small details are extracted from an image using Top-Hat Transformations. Top-hat transformation can be broadly classified into:

White Top-Hat Transform: It is defined as the difference between the input image and its opening by some structuring element.

Black Top-Hat Transform: It is defined as the difference between the closing by some structuring element and the input image. This transforms are applied for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others.

White Top-Hat Transformation:

$$T(I)=I-Iob$$

Where " o" denotes the opening operation. Black Top-Hat Transformation:

$$T_b\ (I)=I\bullet B-I$$

Where "•" is the closing operation. "•"morphologically closed input image. Bottom-Hat Transformation is similar to that of Black Top-Hat Transformation.

$$T_{bh}\ (I)=I-I\bullet b$$

Where "•" is the closing operation.

G. Global Power Law Transform

Global Power Law Transform [8] is given by,

$$S=Cr^{\gamma}$$

This transformation function is also called as gamma correction. Different levels of enhancement are obtained by varying the values of γ. The difference between the log-transformation function and the power-law functions is that using the power-law function a family of possible transformation curves can be obtained just by varying the λ.

H. Adaptive Power Law Transform

Adaptive Power Law Transforms is a modified form of Global Power Law Transform. Contrast variations are reduced between poor and well contrast regions. The proposed APLT adjusts the intensity of each pixel with the exponent in power-law transformation being dynamically set based on the local intensity range of its neighborhood pixels.

I. Spatial Filtering

Spatial filtering removes noise from the image. Filters that are used for the removal of noise are Smoothing and sharpening spatial filters. Smoothing filters are used for blurring and noise reduction. This is also called as average filter or low pass filters. In this technique each and every pixel is replaced by the average of neighborhood pixels. (i.e.) average masking is used.

Sharpening filters are used to enhance the intensity transitions. In an image, crisper the intensity transitions, more sharper the image. The intensity transitions between adjacent pixels are related to the derivatives of the image. Hence, operators are used to compute the derivatives of a digital image

IV. FREQUENCY DOMAIN ENHANCEMENT TECHNQUES

In frequency domain method fourier transform of the image is computed and then enhancement techniques are applied. This frequency domain method involves 3 basic steps,

- Transform the input image into its Fourier transform
- Apply the transfer function
- Inverse Fourier transform is applied to get enhanced image

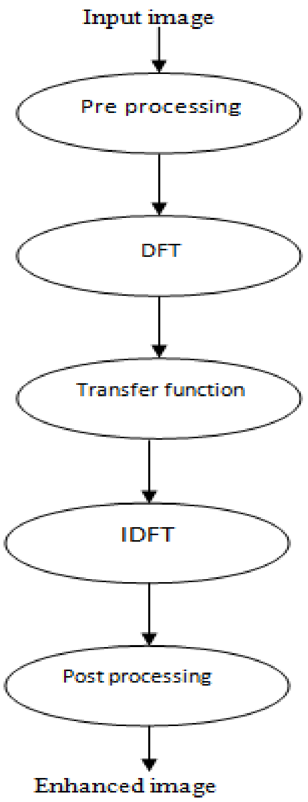

Figure 3: Frequency Domain Enhancement

Image enhancement is applied to modify the image contrast brightness of the pixel. In frequency domain enhancement technique, the pixel value of the output image will be modified according to the transfer function applied to the image. This can be represented as

$$S=T(r)$$

Where, s= pixel value of input image F, r = pixel value of output image G, T = transformation function (H).Filtering is commonly used for frequency domain enhancement. Therefore based on DFT enhancement of image is done. This filtering is classified into low pass and high pass filtering.

V. COMPARISON BETWEEN SPATIAL DOMAIN TECHNIQUE AND FREQUENCY DOMAIN TECHNIQUE

- **Spatial domain** is manipulation of pixels of an image. It is the technique for changing the representation of an image and used in many field such as sharpening and smoothing images. Whereas **Frequency domain** is the manipulation of Fourier transforms to enhance an image and perform purely with convolution theorem and it is used in changing the position of an image.
- The advantage of **spatial domain technique** is that it is simple to understand and the complexity of these techniques is very low which helps in real time implementation. Whereas **Frequency domain** technique having advantages which include low computation complexity, easy to view, manipulation of image's frequency composition and the special transformed domain property is easily applicable.
- The disadvantages of **spatial domain technique** is that it does not provides adequate robustness and perceivably. Whereas the disadvantage of **Frequency Domain** is that it cannot enhance properly every part of an image simultaneously and the automation of image enhancement is also very difficult.

VI. REAL-TIME APPLICATIONS OF IMAGE ENHANCEMENT TECHNIQUES

Image enhancement techniques have contributed to exploration advancement in a various fields. Some of the areas where Image Processing has wide application are as follows:

➢ In forensics, For instance is used for designation, evidence gathering and monitoring. Images obtained from finger-mark detection, security videos analytic thinking and crime scene inspections are enhanced to help out with identification of culprits along with protection of victims.

➢ In atmospheric sciences, For example is used to slow up the effects of haze, fog, mist and turbulent weather conditions for meteorological observations. It can help in detecting shape and also structure of remote physical objects in environment sensing. An artificial image from satellites requires image restoration, enhancement and other filtering methods to remove noise.

➢ Astrophotography faces challenges on account of light and noise contamination that can be lessened by IE. For real-time sharpening and contrast enhancement several cameras have throughout-built IE functions. Furthermore, numerous software, allow editing such images to offer better and vivid final results.

➢ In oceanography the study of images reveals interesting highlights of water flow, sediment density, geomorphology and bathymetric behaviour to name a couple of. These features are to a greater extent clearly observable in graphics that are digitally boosted to overcome the issue of moving targets, scarcity of light and obscure surround.

➢ Medical imaging uses image processing techniques for noise reduction in addition to sharpening the visual representation and details of an image. Since minute details perform a critical role inward diagnosis and treatment involving disease, it is vital to highlight important features spell displaying medical images. This way image processing techniques becomes an important aiding tool for MRI, echography and x-rays images.

CONCLUSION

In this paper, various techniques of enhancement discussed. Point processing enhances the contrast of the image. Image negative is widely used where brighter regions embedded in darker region acts as ROI. This is used in medical image processing. Power law transformation is used for contrast manipulation and for dark images. Frequency domain enhancement methods are used to overcome defects of spatial domain enhancement. In Histogram equalization contrast of the image is enhanced. Spatial filtering is used to remove the noise in the image.

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