IMAGE ENHANCEMENT TECHNIQUES: A REVIEW

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Abstract

Field of image processing has vast applications in medical, forensic, research etc., It includes various domains like enhancement, classification, segmentation, etc., which are widely used for these applications. Image Enhancement is the pre processing step on which the accuracy of the result lies. Image enhancement aims to improve the visual appearance of an image, without affecting the original attributes (i.e.,) image contrast is adjusted and noise is removed to produce better quality image. Hence image enhancement is one of the most important tasks in image processing. Enhancement is classified into two categories spatial domain enhancement and frequency domain enhancement. Spatial domain enhancement acts upon pixel value whereas frequency domain enhancement acts on the Fourier transform of the image. The enhancement techniques to be used depend on modality, climatic and visual perspective etc., In this paper, we present a survey on various existing image enhancement techniques.

Keywords: *Enhancement, Spatial domain enhancement, Frequency domain enhancement, Contrast, Modality.*

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1. 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 [1] image enhancement act on pixels directly. Frequency based domain[2] 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.

2. 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

3. 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.

3.1 Gray Level Transformation

Gray level transformations [1] 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

3.2 Image Negative

Image negative [3], 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

$$s = L - 1 - r \quad \text{-- (1)}$$

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)

3.3 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

$$s = cLog(1+r) \qquad \text{-- (2)}$$

3.4 Histogram Processing

Histogram equalization: Histogram equalization [5] is used for contrast adjustment using the image histogram When 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. It's advantage is, it goes 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.
The histogram equalization formula is given by:

$$h(v) = round\left(\frac{cdf(v) - cdf_{\min}}{(m \times n) - cdf_{\min}} \times (L-1)\right) \qquad \text{-- (3)}$$

3.5 Piecewise Linear Transformation

Contrast Stretching: In contrast stretching [6], 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

$$I_0(x, y) = f(I(x, y)) \qquad \text{-- (4)}$$

Where, the original image is $I(x, y)$, the output image is $I_0(x, y)$ after contrast enhancement, and $T(r)$ the transformation function. The transformation function T(r) is given by (5), and shown in Fig-1.

$$T(r) = s \qquad \text{-- (5)}$$

Where s is,

$$s = \begin{cases} l * r & 0 < r < a \\ m * (r - a) + v & 0 < r < b \\ n * (r - b) + w & 0 < r < l - 1 \end{cases}$$

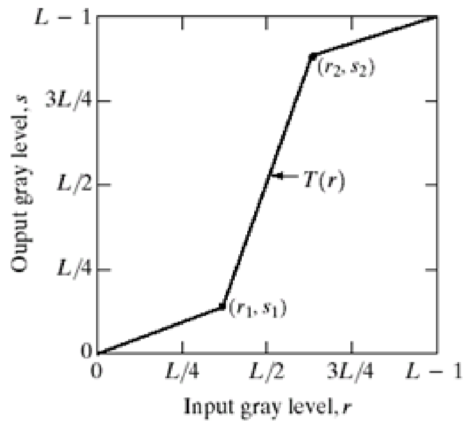

Fig -1: Contrast Stretching- Transformation Function

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.

3.6 Morphological Operators

Top-Hat Transformation: Small elements or ROI or small details are extracted from an image using Top-Hat Transformations [7]. 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:

$$T_w(I) = I - I \circ b \qquad \text{-- (6)}$$

Where "∘ " denotes the opening operation.

Black Top-Hat Transformation:

$$T_b(I) = I \bullet b - I \qquad \text{-- (7)}$$

Where "•" is the closing operation.

Bottom-Hat Transformation: The bottom-hat transformation [7] is used for dark objects on a light background. This operator subtracts input image from morphologically closed input image. Bottom-Hat Transformation is similar to that of Black Top-Hat Transformation.

$$T_{bh}(I) = I - I \bullet b \qquad \text{-- (8)}$$

Where "•" is the closing operation.

3.7 Global Power Law Transform

Global Power Law Transform [8] is given by,

$$S = cr^{\gamma} \qquad \text{-- (9)}$$

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.

3.8 Adaptive Power Law Transform

Adaptive Power Law Transforms [9] 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. The mathematical expressions of APLT are as follows:

$$g'(x,y) = g(x,y)^{\gamma} \qquad \text{-- (10)}$$

$$\gamma = \ln\left(\frac{1}{d(x,y)}\right) \qquad \text{-- (11)}$$

$$d(x,y) = \max\{g(x+p, y+p)\} - \min\{g(x+p, y+p)\} \qquad \text{-- (12)}$$

Where,

$p = -[w/2] \sim [w/2]$

$q = -[w/2] \sim [w/2]$

Where $g(x,y)$ is the intensity of pixel at (x,y), w is the size of a window centered at (x,y)

3.9 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 [10] 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.

$$\frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix} \qquad \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

Fig -2: Averaging Filter

Sharpening filters [11] 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.

The figure shows some of the spatial filters

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \qquad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Fig -3: Laplacian operator

$$\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \qquad \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

Fig -4: Robert operator

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \qquad \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Fig -5: Sobel operator

4. FREQUENCY DOMAIN ENHANCEMENT TECHNQUES

In frequency domain method [2] [11] 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

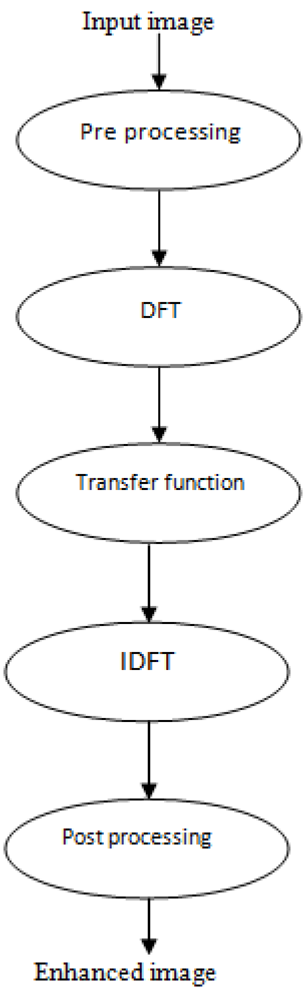

Fig -6: Frequency domain enhancement

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

$$s = T(r) \quad \text{-- (13)}$$

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.

5. 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.

REFERENCES

[1]. R. C. Gonzalez, Richard E. Woods, Digital Image processing, Addision-Wesely, 2003
[2]. Yusra Banday, R.Swaminathan, "Survey of Image Enhancement Techniques in Wavelet Domain", International Journal of Latest Technology in Engineering, Management & Applied Science, ISSN 2278-2540
[3]. Suneetha, Venkateswaralu, "Enhancement Techniques for Gray Scale Image in Spatial Domain", International Journal of Emerging Technology and Advanced Engineering, ISSN: 2250-2459
[4]. Foisal Hossain, "Image Enhancement Based on Lograthmic Transform Co-efficient and Adaptive Histogram Equalization", International Conference on Convergence Information Technology.
[5]. Rajesh Garg, Bhawna Mittal, "Histogram Equalization Techniques for Image Enhancement", International Journal of Current Engineering and Technology, ISSN: 2230-7109
[6]. Raman Maini, Himanshu Aggarwal, "Comprehensive Review on Image Enhancement Technique" Journal of Computing ISSN: 2151-9617
[7]. Suman Thapar, "Study and Implementation of Various Morphology Based Image Contrast Enhancement Techniques", International Journal of Computing & Business Research ISSN (Online): 2229-6166.
[8] Vimal, Thiruvikraman,"Automated Image Enhancement using Power Law Transformation", Indian Academy of Sciences.
[9]. Chun-Ming Tsai, "Adaptive Local Power Law Transformation for Color Image Enhancement", International Journal on Applied Mathematics and Information Science, ISSN: 2019-2026
[10]. Saruchi, Madan Lal, "Comparative Study Different Image Enhancement Techniques", International Journal of Computers & Technology ISSN 2277-3061
[11]. Bedi, Rati Khandelwal, "Various Image Enhancement Techniques: A Critical Review", International Journal of Advanced Research in Computer and Communication Engineering, ISSN: 2278-1021

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