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Image Enhancement Techniques- A Review

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Abstract: ***Image enhancement is one of the important steps of the digital image processing. Image enhancement is done to enhance the images for better interpretation. There are many ways of enhancing the images. Basically, the techniques are divided into two domains: Spatial Domain and Frequency Domain. Some parameters to show the effectiveness of various methods of image enhancement are Peak Signal to Noise Ratio, Mean Square Error, Mean, Standard Deviation, Median Angular Error and Bit Error Rate. In this paper, a review on image enhancement techniques is done.***

Keywords: Spatial Domain, Frequency Domain, MSE, PSNR, BER, Median Angular Error, Mean, Standard Deviation.

I. INTRODUCTION

Images are important because they provide information. Images are useful in various fields like agriculture, geology, forestry, weather forecast and education. But usually these images are blurred or have low intensity values. The contaminated image sensors add noise to the captured images. There are different types of noise like Gaussian noise which is additive noise, speckle noise which is multiplicative noise. The insufficient enlightenment is also responsible for degradation of the images. So there is need of image enhancement for better interpretation of the images. The image enhancement is vital step of digital image processing. It is used to enhance the images and used to highlight specific part of the images. The following figure shows image enhancement [1].

Fig. No. 1 Image Enhancement

II. TYPES OF IMAGE ENHANCEMENT TECHNIQUES

There are various types of image enhancement techniques. The image enhancement techniques are mainly divided into two domains:

2.1 Spatial Domain: In this technique, the dealing is with the pixels directly. The values of the pixels are manipulated to get the desired enhancement. The common examples of techniques which are under spatial domain are Logarithmic Transforms, Histogram Equalization and Power Law Transforms. These techniques are based upon the direct manipulating of the pixel values. The spatial domain is commonly used for changing the grey-level values of the pixels so the contrast enhancement is achieved. In the histogram equalization technique, the enhancement is obtained by uniformly distributing the pixel values so the enhanced images have a linear cumulative histogram [2]. There are some histogram equalization methods like Bi-histogram equalization methods, Multi histogram equalization methods and Clipped histogram equalization methods. In the Logarithmic transformation a narrow range of low gray levels are mapped into a wider range of gray levels and by doing so the values of the brighter pixels are expanded and values of the darker pixels are compressed [3]. In the Power Law transformation, mapping of the narrow range of the dark pixel values into the wider range and wider ranges of the bright pixel values to the narrow range is done which enhances the images [3]. In the following figure, image enhancement is done by spatial domain technique [4]:

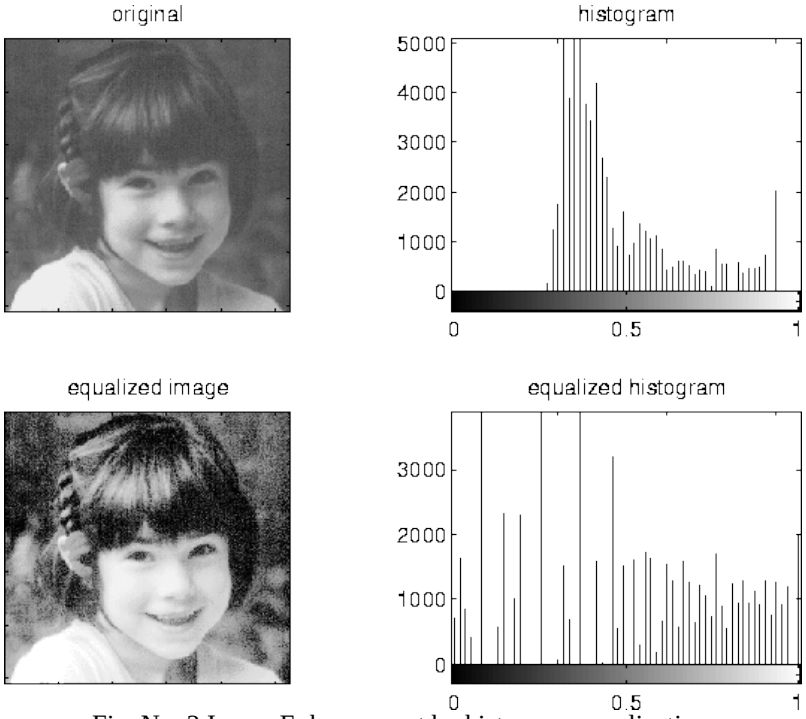

Fig. No. 2 Image Enhancement by histogram equalization

2.2 Frequency Domain: In this technique, Fourier Transformation concept is used. The orthogonal transformation of the image is done. The principle which is used in the frequency domain techniques consist the computation of a 2-D discrete unitary transform of the image, for instance the 2-D DFT, manipulating the transform coefficients by an operator M, and then performing the inverse transform [5]. In the orthogonal transformation of the image, phase and magnitude are included.

III. PARAMETERS USED FOR MEASURING EFFECTIVENESS OF IMAGE ENHANCEMENT TECHNIQUES

The effectiveness of the image enhancement techniques can be measured in terms of some parameters. These parameters are:

3.1 Mean Square Error: MSE represents cumulative squared error between the enhanced and original image and its formula is [6]:

$$\mathrm{MSE} = \frac{\sum_{M,n}[I1(m,n) - I2(m,n)]^2}{MN} \quad \ldots. (1)$$

where M is defined as number of rows and N is defined as number of columns in the input images, I_1 is defined as the original image and I_2 is defined as the thresholded image or optimized image.

3.2 Peak Signal to Noise Ratio (PSNR): PSNR represents a measure of the peak error [4].PSNR can be defined as [6]:

$$\mathrm{PSNR} = 10\log_{10}\left(\frac{R^2}{\mathrm{MSE}}\right) \quad \ldots. (2)$$

3.3 Bit Error Rate (BER): Bit error rate is defined as the ratio of how many bits received in error to the total number of bits received.

3.4 Median Angular Error: The median angular error is another parameter for measuring effectiveness of the image enhancement techniques.

3.5 Mean: Mean is the average of all intensity value [4]. It is denoting the average brightness of the image.

3.6 Standard Deviation: Standard Deviation is denoting the deviation of the intensity values about mean [6].

IV. RELATED WORK

Image enhancement techniques are used to enhance the different types of images. There are various techniques that are used to enhance the images to make them better for interpretation. A technique using Stationary Wavelet Transform (SWT) and Discrete Wavelet Transform (DWT) has been proposed to enhance the images [7]. The results are showing the superiority of this technique over the conventional techniques and the state-of-the art techniques. A novel technique which uses Discrete Wavelet Transform (DWT) and Singular Value Decomposition (SVD) has been presented for image enhancement of the fingerprints [8]. DWT is used to divide the images into four sub-bands (LL, LH, HL and HH) of the images.

Another novel technique in which Cuckoo Search Algorithm is used with DWT-SVD for enhancing the satellite images [6]. In this technique, the DWT technique is used to decompose the input image and then Cuckoo Search Algorithm is used to enhance each sub-band of the images. Then SVD is applied on the LL sub-band and finally Inverse Discrete Wavelet Transform (IDWT) is applied to get the enhanced image. An Adaptive Neighborhood technique is present for contrast enhancement of MRI images [9].A novel contrast enhancement technique in which DCT and SVD used for

contrast enhancement in which enhancement is done because of the scaling of the DCT coefficients [10]. Another technique for image enhancement in which histogram equalization based on genetic algorithm is presented which shows better results [11]. The image enhancement of underwater images is done by wavelength decomposition and dehazing [12]. Also image enhancement has been proposed by using WT-TNN [13].

V. CONCLUSION

Image enhancement is necessary for making the images more interpretable so that maximum information should be obtained from them. There are many reasons that degrade the images. Many techniques exist for enhancing the images. There are two main domains of image enhancement techniques: Spatial Domain and Frequency Domain. These techniques are offering a wide variety of approaches but the choice is depending on the specific task, image content and viewing conditions. Spatial techniques enhance the images at different levels because spatial operations have been performed in the local neighborhood of pixels. But spatial techniques may enhance noise in excess along with the image or may smoothen image in the areas where accurate details are needed. In the Frequency domain techniques, certain artifacts may be introduced in the images after enhancement of the images. Now researchers are finding new techniques that enhance the images without loss of information or blurring of the image.

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