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Brightness preserving and contrast enhancement of various Image Enhancement Techniques: A review

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ABSTRACT: In digital image processing, image enhancement is one of the essential features of image which is used to improve the visual appearance of than original image and to make is more suitable for use in specific application. This process has wide area of application such as medical, industry, forensic, military etc. The improvement of image can be done by removing noise, blurring and contrast enhancing and for these various image techniques has been developed such as histogram equalization. In this paper, a comprehensive review on image enhancement techniques in spatial and frequency domain with their merits and demerits.

Keywords: Noise, Contrast, Spatial Domain, Frequency Domain, Histogram

I. INTRODUCTION

Digital image processing is a broad subject and often involves procedures which can be mathematically complex, but central idea behind digital image processing is quite simple. The ultimate aim of image processing is to use data contained in the image to enable the system to understand, recognize and interpret the processed information available from the image pattern. Image enhancement technique improve the quality of an image by taking input as low quality image and by giving output as high quality image for particular application. Digital image enhancement techniques are used to get detail that is not cleared, or to highlight certain features of interest in image. In image enhancement process one or more attributes of image are modified. Image enhancement can be applied to different areas of science, engineering and medical diagnostic. Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques [1]. The prime objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Image enhancement is a subjective process. Observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods. There exist many techniques that can enhance a digital image without spoiling it. Carrying out image enhancement understanding under low quality image is a challenging problem because of these reasons. Due to low contrast, we cannot clearly extract objects from the dark background. Most color based methods will fail on this matter if the color of the objects and that of the background are similar [2]. The review of available techniques is based on the existing techniques of image enhancement, which can be classified into two broad categories:

- Spatial Domain Enhancement Techniques
- Frequency Domain Enhancement Techniques.

Spatial based domain image enhancement improves quality of image by directly manipulating the pixels value. The main advantage of spatial based domain technique is that they conceptually simple to understand and the complexity of these techniques is low which is useful in real time implementations [3]. But these techniques generally lacks in providing adequate robustness and imperceptibility requirements. The spatial filtering process consists simply moving the filter mask from point to point in an image. At each point, the response of the filter at that point is calculated using a predefined relationship. Spatial filters can be further classified into linear and non-linear filters.

Linear filtering is filtering in which the value of an output de-noised pixel is a linear combination of the values of the pixels in the input pixel's neighborhood.

Whereas a filter is said to non-linear if its output is not a linear function of input [4]. 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 transform coefficients of the image, such as Fourier transform, discrete cosine transform, curvelet transform and wavelet transform. The filters in frequency domain are more effective than in spatial domain while reducing noises because it is to identify noise in frequency domain. When an image is transformed into the Fourier domain, the low frequency components usually correspond to smooth regions or blurred structures of the image, whereas high-frequency components represent image details, edges, and noises. Thus, one can design filters according to image frequency components to smooth images or remove noise.

II. DIFFERENT NOISE IN DIGITAL IMAGE

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera [5]. The noise in the digital medical images is due to transmission media, acquisition noise by equipment, image quantization and other organs such as body fat and breathing motion, which degrades the quality of image as a result area of interest is difficult to study. Image noise is considered as an undesirable by-product of image capture. These unwanted fluctuations are known as "noise" by analogy with unwanted sound they are inaudible .The noise has also some benefits in some applications, such as dithering [5]. The characteristics of noise depend on its source. The filter or the operator which best reduces the effect of noise also depends on the source. The types of noise are following:-

A. Gaussian Noise

The standard model of amplifier noise is additive, Gaussian, independent at each pixel and independent of the signal intensity [6]. Gaussian noise is statistical noise and it has its probability density function equal to that of the gaussian distribution. In other words, the values that the noise can take on are Gaussian-distributed. A special case is white Gaussian noise, in which the values at any pairs of times are statistically independent. In applications, Gaussian noise is most commonly used as additive white noise to yield additive white Gaussian noise. If the white noise sequence is a Gaussian sequence, then is called a white Gaussian noise (WGN) sequence [5]. It has a bell shaped probability distribution function given by,

$$P(z) = \frac{1}{\sqrt{2\Pi\sigma^2}} e^{\frac{-(z-m)^2}{2\sigma^2}}$$

where z represents the gray level, m is the mean of the function, and σ is the standard deviation of the noise. Practical results of adding Gaussian noise in MATLAB are given below.

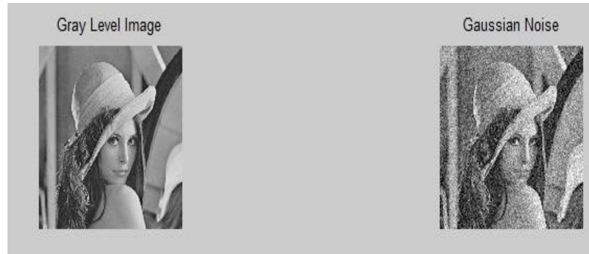

Fig. 1. Digital Image with Gaussian Noise.

B. Salt and Pepper Noise

Salt and Pepper noise also known as an impulse noise. We can also referred it as intensity spikes. The value of these spikes can be either 0 or 1. The pixels which are corrupted are set alternatively to maximum or the minimum value which gives the image a salt and pepper like structure. The main cause of salt and pepper noise is data transmission error. As compared to additive noise this impulse noise is difficult to remove. An image containing salt-and-pepper noise will have dark pixels in bright regions and bright pixels in dark regions [7]. Along with data transmission error the Salt and Pepper noise can be caused by dead pixels, analog-to-digital converter errors etc. This noise is named for the salt and pepper appearance an image takes on after being degraded by this type of noise [6,7]. The probability distribution function for Salt and Pepper noise is given by,

$$P(z) = \begin{pmatrix} P_a & for\ z = a \\ P_b & for\ z = b \\ 0 & otherwise \end{pmatrix}$$

Where z represents gray level, if b>a , gray level b will appear as a light dot in the image. Conversely, level a will appear like a dark dot. Practical results of adding Gaussian noise in MATLAB are given below.

Fig. 2. Digital Image with Salt and Pepper Noise.

C. Speckle Noise

Speckle is a particular kind of noise which occurs in images obtained by coherent imaging systems like ultrasound. The coherent imaging in simple terms is lensless imaging. Speckle noise is a multiplicative noise which occurs in the coherent imaging, while other noises are additive noise. Speckle is caused by interference between coherent waves that, backscattered by natural surfaces, arrive out of phase at the sensor [7]. Speckle can be described as random multiplicative noise. This type of noise is an inherent property of medical ultrasound imaging. and because of this noise the image resolution and contrast become reduced, which effects the diagnostic value of this imaging modality. So, speckle noise reduction is an essential preprocessing step, whenever ultrasound imaging is used for medical imaging [8]. The probability distribution function for speckle noise is given by gamma distribution,

$$P(z) = \frac{z^{\alpha - 1}}{(\alpha - 1)!\,a^{\alpha}} e^{-z/a}$$

Where z represents the gray level and variance is $a^2\alpha$. Practical results of adding Gaussian noise in matlab are given below.

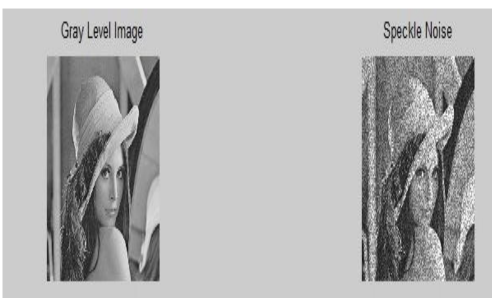

Fig. 3. Digital Image with Speckle Noise.

D. Uniform Noise

The uniform noise cause by quantizing the pixels of image to a number of distinct levels is known as quantization noise. It has approximately uniform distribution. In the uniform noise the level of the gray values of the noise are uniformly distributed across a specified range. Uniform noise can be used to generate any different type of noise distribution. This noise is often used to degrade images for the evaluation of image restoration algorithms. This noise provides the most neutral or unbiased noise.

Uniform noise:

$$p(z) = \begin{cases} \frac{1}{(b-a)} & \text{if } a \le z \le b \\ 0 & \text{otherwise} \end{cases}$$

$$\mu = (a+b)/2; \qquad \sigma^2 = (b-a)^2/12$$

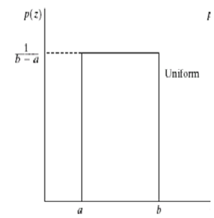

Fig. 4. PDF of Impulse Noise.

E. Rayleigh Noise

Radar range and velocity images typically contain noise that can be modeled by the Rayleigh distribution.

Rayleigh noise:

$$p(z) = \begin{cases} \frac{2}{b}(z-a)e^{-(z-a)^2/b} & \text{for } z \ge a \\ 0 & \text{for } z < a \end{cases}$$

$$\mu = a + \sqrt{\pi b/4}; \qquad \sigma^2 = \frac{b(4-\mu)}{4}$$

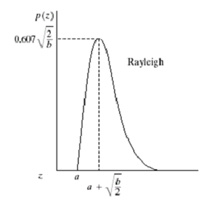

Fig. 5. PDF of Rayleigh Noise.

III. NEED OF IMAGE ENHANCEMENT

Image enhancement is subjective process of improvement and is application dependent [9[. Apart from visible region, digital images can also be created from remaining electromagnetic spectrum like x-rays, infrared rays, gamma rays etc. some of areas in which image enhancement widely used are given below.

- In atmospheric sciences, image enhancement is used to reduce the effects of haze, fog, and turbulent weather for meteorological observations. Image enhancement helps in detecting shape and structure of remote objects in environment sensing. Satellite images undergo image restoration and enhancement to remove noise.
- In Medical Diagnosis, de-noising of medical images is important because in order to get good result of diagnosis, the area of interest in digital medical images must be sharp, clear and free from noise. A medical image can be corrupted with noise during acquisition, transmission, storage and the retrieval process. Most commonly speckle noise occurs in medical images which are inherited in coherent images.
- In Study of Oceans images reveals interesting features of water flow, sediment concentration, geomorphology and bathymetric patterns to name a few.

These features are more clearly observable in images that are digitally enhanced to overcome the problem of moving targets, deficiency of light and obscure surroundings.

The number of other fields including security, manufacturing, satellite images, microbiology, biomedicine, bacteriology, etc., benefit from various image enhancement techniques. These benefits are not limited to professional studies and businesses but extend to the common users who employ image enhancement to cosmetically enhance and correct their images.

IV. IMAGE ENHANCEMENT TECHNIQUES

A. Histogram Processing

A histogram is a chart based representation of the distribution of data. An image histogram is a representation of the number of pixels in an image as a function of their intensity. The histogram equalization technique is used to stretch the histogram of the given image in order to distribute uniformly among all intensity levels. The histogram distributed uniformly means that the contrast of the image is good [10]. In other words if the contrast of the image is to be increased then it means the histogram distribution of the corresponding image needs to be widened. Histogram equalization is the most widely used enhancement technique in digital image processing. In an image processing context, the histogram of an image normally refers to a histogram of the pixel intensity values. The histogram is a graph showing the number of pixels in an image at each different intensity value found in that image. For an 8-bit grayscale image there are 256 different possible intensities, and so the histogram will graphically display 256 numbers showing the distribution of pixels amongst those grayscale values. Several variations are made for improvement of histogram equalization based contrast enhancement which are given below.

- Brightness Preserving Bi-Histogram Equalization
- Dualistic Sub-image Histogram Equalization
- Recursive Mean-Separate Histogram Equalization
- Mean Brightness Preserving Histogram Equalization
- Dynamic Histogram Equalization
- Brightness Preserving Dynamic Histogram Equalization

B. Local Enhancement

Previous methods of histogram equalizations and histogram matching are global. So, local enhancement [15] is used. Define square or rectangular neighborhood (mask) and move the center from pixel to pixel. For each neighborhood, calculate histogram of the points in the neighborhood. Obtain histogram equalization/specification function. Map gray level of pixel centered in neighborhood. It can use new pixel values and previous histogram to calculate next histogram.

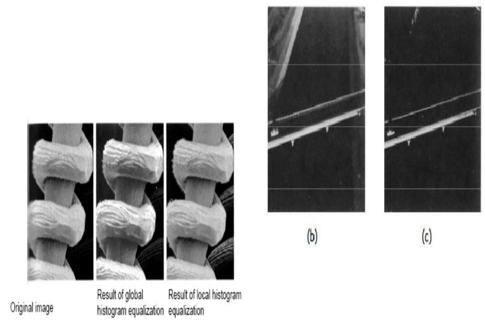

Fig. 6. Histogram Processing.

C. Logarithmic Transformations

The general form of the log transformation is

$$s = c * \log (1 + r)$$

The log transformation maps [16] a narrow range of low input grey level values into a wider range of output values. The inverse log transformation performs the opposite transformation. Log functions are particularly useful when the input grey level values may have an extremely large range of values. In the following example the Fourier transform of an image is put through a log transform to reveal more detail

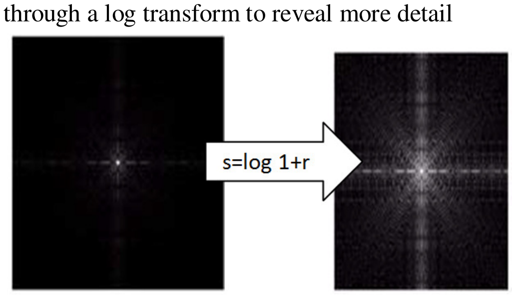

Fig. 7. Example showing effect of Logarithmic transformation.

$s = log(1 + r)$

We usually set c to 1. Grey levels must be in the range [0.0, 1.0]

D. Piecewise Linear Transformation

Here pixel alteration is done through a random user defined transformation [18]. Stretching and contrasting is performed by changing original pixel values to new values hence making it more clearer, brighter and contrast adjusted.

Like here, different values of (r1,s1) and (r2,s2) produce transformation which enhances the input image to new improved image.

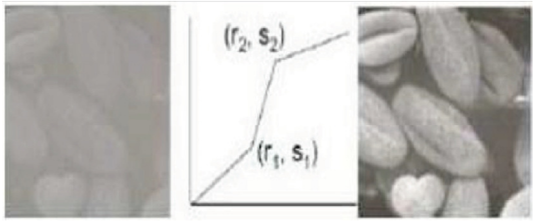

Fig. 8. Original Image and Its Stretched Image [10].

E. Threshold Transformation

Thresholding transformations are mostly effective for partitioning the image elements in which we wish to segregate a desired object from the background [18]. 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'

F. 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 transition 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 $b=(n-1)/2$

G. Unsharp Masking

In this enhancement is performed by adding a fraction of high

pass filtered image to the original one [19]. Input output relation can be stated as:

X = x + YZ

Where X = output image

x = input image

Y = fraction of high pass filtered

Z = Image

Image enhancement modifies the contrast and brightness of the pixel. In the frequency domain, pixel value is modified as per applied transfer function. In this, filtering is not rare to use. So this enhancement technique is based on DFT and is classified into low and high pass filtering. Although simple, easy and efficient but it has a major drawback of enhancing noise as well. Moreover, enhancement of sharp transitions lead to excessive overshoot on sharp edges.

H. Powers-Law Transformations

The nth power and nth root curves indicated in fig. A can be given by the statement, This transformation function is also called as gamma correction. For different estimations of γ distinctive levels of enhancements can be obtained. This procedure is usually called as Gamma Correction. In the event that you recognize, distinctive display monitors display images at diverse intensities and clarity. That implies, each monitor has built-in gamma correction in it with certain gamma ranges thus a good monitor consequently amends all the images showed on it for the best contrast to give user the best experience. The difference between the log transformation function and the power-law functions is that utilizing the power-law function a family of possible transformation curves can be obtained just by varying the λ. These are the three essential image enhancement functions for grey scale images that can be connected effortlessly for any sort of image for better contrast and highlighting. Utilizing the image negation formula given above, it is not necessary for the outcomes to be mapped into the grey scale range [0, L-1]. Yield of L-1-r naturally falls in the scope of [0, L-1]. Be that as it may for the Log and Power-Law transformations resulting values are frequently quite distinctive, depending upon control parameters like λ and logarithmic scales.

So the consequences of these values ought to be mapped back to the grey scale range to get a meaningful output image. For instance, Log function s = c log (1 + r) brings about 0 and 2.41 for r varying between 0 and 255,keeping c=1. Along these lines, the extent [0, 2.41] ought to be mapped to [0, L-1] for getting a meaningful image.

V. CONCLUSION

The quality of images must be improved to get essential information for performing any task. With the addition of different noises in images it distorts or does not obtain the clear image. To improve the contrast or the visibility appearance of images various image enhancement technique has be developed such as histogram equalization, filtering and classification etc. This paper presents the comprehensive review of the literature related to image enhancement. After reviewing these techniques it has been analyzed that the some approach is better to de-noise the image and enhance the contrast of image but some are less efficient. So in future work design such methodology which uses the advantages of spatial domain and frequency domain techniques of image enhancement.

REFERENCE

[1]. R. W.Jr. Weeks, (1996). Fundamental of Electronic Image Processing. Bellingham: SPIE Press.

[2]. Bhabatosh Chanda and Dwijest Dutta Majumder, 2002, Digital Image Processing and Analysis.

[3]. R. Jain, R. Kasturi and B.G. Schunck, Machine Vision, McGraw-Hill International Edition, 1995.

[4]. Bhabatosh Chanda and Dwijest Dutta Majumder, 2002, Digital Image Processing and Analysis.

[5]. Raman Maini, Himanshu Aggarwal, "Comprehensive Review on Image Enhancement Technique" *Journal of Computing* ISSN: 2151-9617.

[6]. Palwinder Singh, Leena Jain, "Noise reduction in ultrasound images using wavelet and spatial filtering techniques", *IEEE conference IMKE-2013*, Pg. 57.

[7]. Suman Thapar, "Study and Implementation of Various Morphology Based Image Contrast Enhancement Techniques", *International Journal of Computing & Business Research* ISSN (Online): 2229-616.

[8]. Suman Thapar, "Study and Implementation of Various Morphology Based Image Contrast Enhancement Techniques", *International Journal of Computing & Business Research* ISSN (Online): 2229-6166.

[9]. Rajesh Garg, Bhawna Mittal, "Histogram Equalization Techniques for Image Enhancement", *International Journal of Current Engineering and Technology*, ISSN: 2230-7109.

[10]. Y.-T. Kim, "Contrast enhancement using brightness preserving bi-histogram equalization," *IEEE Trans. on Consumer Electronics*, Vol. **43**, pp.1-8, February 1997.

[11]. V. Sltrela. "Denoising via block Wiener filtering in wavelet domain". In 3rd European Congress of Mathematics, Barcelona, July 2000. Birkhäuser Verlag.

[12]. H. Zhang, A. Nosratinia, and R. O. Wells, "Image denoising via wavelet-domain spatially adaptive FIR Wiener filtering", in IEEE Proc. *Int. Conf. Acoust., Speech, Signal Processing, Istanbul, Turkey*, June 2000.

[13]. Y. Xu, J. B. Weaver, D.M. Healy, and J. Lu, "Wavelet transform domain filters: a spatially selective noise filtration technique," *IEEE Trans. Image Proc.*, vol. **3**, no. 6, pp. 747–758, Nov. 1994.

[14]. S.Sudha, G.R.Suresh and R. Sukanesh, "Speckle Noise Reduction in Ultrasound Images by Wavelet Thresholding based on weighted Variance", *International Journal of Computer Theory and Engineering,* Vol. **1**, No. 1, April [3] A. Name, "Dissertation Title", M.S.(or Ph.D.) thesis, Department, University, City, Country, Year.

[15]. S. E. Umbaugh, "Computer Vision & Image Processing," Prentice Hall PTR, 1998.

[16]. R. Jain, R. Kasturi and B.G. Schunck, Machine Vision, McGraw-Hill International Edition, 1995.

[17]. Sharma, Juliastuti, E., L. Epsilawati, "Image contrast enhancement for film-based dental panoramic radiography", *In System Engineering and Technology (ICSET), 2012 International Conference,* Vol. **8,** 2012, pp. 1-5, IEEE.

[18]. S. C. Pei, Y. C. Zeing, and C. H. Chang; *Virtual restoration of ancient chinese painting using color contrast enhancement and lacuna texture synthesis*; *IEEE Trans. Image Processing*, Vol. **13**, pp. 416-429,2004.

[19]. Bhattacharya Saumik, Sumana Gupta, Subramanian Venkatesh K., "Localized image enhancement", *In Communications (NCC), 2014 Twentieth National Conference,* Vol. **5**, pp. 1-6, IEEE, 2014, pp. 1-6.