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Image Enhancement and Noise Filtering By Using Extended Fast Fourier Transformation Algorithm.

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ABSTRACT:
In this paper, image enhancement and noise filtering technique using extended Fast Fourier transformation function [1] is presented. The image enhancement and the denoising operations are coupled in this newly developed algorithm. In this method multiplication factor,

$$n\left(\frac{\sin \pi x}{\pi x}\right)$$

we used that factor n to determine the most degree of the contrast depending on the degree of darkness or brightness of the original image, is multiplied to the Fourier transformed image, and image is reconstructed using inverse Fourier transform. The experiment result shows notable subjective improvement in terms of quality. Moreover its computational complexity is also less. In this paper we proposed a contrast enhancement technique without affecting the mean brightness of the images and also denoises the image. The experimental results show that we are able to enhance the contrast of the input image without making any significant effect on the mean brightness of the image.
Index terms: De-noiseing, Enhancement factor, Fast Fourier transform, Image enhancement, Inverse Fourier transform & Sinc(x) function.

1: Introduction:

Good contrast in any image is a basic requirement to get a better perception of the image. Images with low contrast contain details which are not clearly visible and by enhancing the contrast of given image one can make these details more clearly visible. Such contrast enhancement techniques are able to produce output images with better appearance and high detailing as compare to the input images by increasing the gray-level differences among objects and background.

Numerous enhancement techniques are available in the literature: we can classify them in two basic classes: 1) Frequency domain techniques that decompose an image into high and low frequency signals for manipulation [2] and 2) Spatial domain techniques. [3]-[6] are some other algorithms which are developed for contrast enhancement .The most popular technique for contrast enhancement of images is histogram equalization (HE) [7-11]. It is one of the well-known methods for enhancing the contrast of a given image in accordance with the samples distribution [12] [13]. HE is a simple and effective contrast enhancement technique which distributes pixel values uniformly such that enhanced image have linear cumulative histogram. It stretches the contrast of the high histogram regions and compresses the contrast of the low histogram regions [14].The HE technique is a global operation hence; it does not preserve the image brightness. HE has been widely applied when the image needs enhancement, such as medical image processing, radar image processing, texture synthesis, and speech recognition [15-17]. HE usually introduces two types of artifacts into the equalized image namely over-enhancement of the image regions with more frequent gray levels, and the loss of contrast for the image regions with less frequent gray levels [18 .].To overcome this drawback several HE-based techniques are proposed and are more focused on the preservation of image brightness than the improvement of image contrast. In 1997, D.J.Jobson et al. [19] proposed another interesting approach for image contrast enhancement. Authors of [19] suggest that intensity conversion is done for each pixel, which is based on the information of local regions with various sizes and thus provide fine conversion on various images. One main drawback of this method is that, it takes lot of time for computation and needs a huge calculation.

Presence of noise is also one of the biggest problems in application in computer graphics. Noise is defined as the random gray level variations within an image that have no spatial dependencies from image to image. Noise always degrades the quality of images. Noise gets introduced into the data via any electrical system used for storage, transmission, and/or processing. When encountering an image corrupted with noise you will want to improve its appearance for a specific application. When one would like to remove the noise, it follows certain filtering operation where the signal has to be passed through a filter and the filter in turn removes the undesirable components [20].

In this paper by applying enhancement factor n to the output obtained from Fast Fourier transformed image the contrast of the input image can be enhanced at a similar rate to block-overlapped histogram equalization while the complexity can be reduced considerably. The proposed method is a modification of Fourier transform method and it also preserves the mean brightness of the image. Its computational complexity is also less.

Organization of this paper is as: Section 2 briefly covers some preliminaries related to this paper. Section 3 describes the proposed method in detail. Section 4 presents' experimental results and comparison of results with histogram equalization method. Section 5 covers simulation of results and then the paper concludes in section 6.

2 Preliminaries

In this section, we briefly describe Sinc(x) function.

A:Sinc(x) Function: Sinc(x) function is the continuous mathematical function. This function goes smoothly and kindly.

$$\mathrm{sinc}(x) = \begin{cases} 1 & for\ x = 0 \\ \frac{\sin x}{x} & otherwise \end{cases} \quad (1)$$

In image processing, we can use Sinc function which is output of FFT transform of the input image as histogram transformation function for enhancing the contrast in the low contrast images.

In digital image processing and digital signal processing the normalized sinc function is defined by

$$Sinc(x) = \frac{\sin(\pi x)}{\pi x} \quad (2)$$

The normalization causes the definite integral of the function over the real numbers to equal 1 whereas the same integral of the unnormalized sinc function has a value of π [21-22]. In both cases, the value of the function at the removable singularity at zero is 1. In image processing, we can use Sinc function as a transformation function for enhancing the contrast.

In this method filter function n (sin Πx /Πx) with n=1, 2, 3 ...etc, is operated on image. A graph is plotted for different values of n. The curve gets enhanced along the y axis as the value of n increases and side lobes moves more and more towards the origin as shown in the Figure 1.

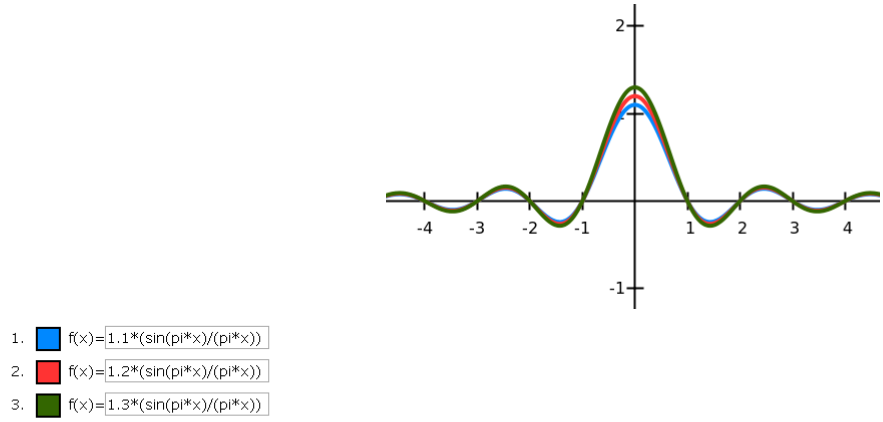

Figure 1: Sinc(x) function multiplied by different enhancement factor n=1.1, 1.2 and 1.3

B: Noise Models: When it has been discussed on the noise it can be getting introduced in the image, either at the time of image generation (or) at the time of image transmission. Some examples of noise are: Gaussian or White, Rayleigh, Shot or Impulse, periodic, sinusoidal or coherent, uncorrelated, and Salt and pepper noise. Salt-Pepper noise [23] appears as black and/or white impulse of the image. The only method to remove noise is by filtration either by using spatial domain filters or by using frequency domain filters. The noise removal has attracted much attention on areas such as computer vision, remote sensing, medical imaging and quality inspection, etc.

3 Proposed Method

In this section we describe the proposed method which is an extension of Fast Fourier Transformation method. The procedure is as follows:

Procedure 1: Consider an input image (grey). The original image must be composed of N rows by N columns, where N is the power of two, i.e., 256, 512, etc. [24]. If the size of the original image is not a power of two, pixel with a value of zero are added to make it the correct size. Let A(x; y) be a pixel value of an input image and normalized pixel value of input image is defined as:

$$A'(x,y) = \frac{A(x,y)}{255} \qquad (3)$$

Procedure 2: We perform Fast Fourier transform (FFT) on the normalized image. The FFT algorithm is used to transform the input image into the frequency domain. This results in the real and imaginary parts of the image being convolved. Convolution in the spatial domain with the rectangle function is equivalent in the frequency domain to multiplication with a Sinc(x) function. Sinc(x) function has prominent side lobes and infinite extent,

Procedure3: We multiply the Fourier transformed image by factor $n\left(\frac{\sin \pi x}{\pi x}\right)$

Say n (say 1.1).When Sinc(x) is multiplied with multiplication factor the side small lobes shifts more and more towards the origin. And thus contrast of the image gets enhanced.

Procedure 4: Then we perform inverse Fourier transform to the output obtained from procedure 3.Taking the inverse FFT completes the algorithm by producing the final convolved image.

4: Experimental Result:

In this section, we evaluate the performance of proposed method with HE method. We would like to show the performance of proposed method in terms of image quality and perceptual visual quality assessment.

(A)Image Quality Assessment: In image quality assessment we are using metrics such as AMBE (Absolute Mean Brightness Error) and RMSC (Root Mean Square Contrast).

(1) Absolute Mean Brightness Error (AMBE): AMBE is used to assess the degree of brightness preservation. Mathematical expression to calculate AMBE is given as:

$$AMBE(X,Y) = |Mean(X) - Mean(Y)| \quad (4)$$

where, Mean(X) and Mean(Y) are the input and output mean brightness, respectively. Smaller value of AMBE shows mean brightness of input and output are almost equal.

(2) Root Mean Square Contrast (RMSC): RMSC is used to calculate the overall luminance contrast in an image. RMSC is defined as the standard deviation of the pixel intensities:

$$RMSC = \sqrt{\frac{1}{P \times Q} \sum_{i=0}^{P-1} \sum_{j=0}^{Q-1} (I_{ij} - \bar{I})^2} \quad (5)$$

Where, intensities are the ith jth element of the two dimensional image of size P by Q. is the average intensity of all pixel values in the image. The image is assumed to have its pixel intensities normalized in the range [0, 1].

(B)Perceptual visual quality assessment: In perceptual visual quality assessment we are using PSNR (Peak –signal to noise ratio).

1) Peak –signal to noise ratio (PSNR): Mathematical expression to calculate PSNR is given as:

$$PSNR = 10\log_{10} \frac{(\max(Y(i,j)))^2}{MSE} \quad (6)$$

With

$$MSE = \frac{\sum_i \sum_j |X(i,j) - Y(i,j)|^2}{N} \quad (7)$$

Where, max(Y (i,j)) is the maximum possible intensity value of the processed image.MSE is the Mean Squared Error and N is the total number of the pixels in the processed image. X (i,j) and Y(i,j)are the input and processed image, respectively.

Image	Metric	n=2	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10
Barbara	MSE	0.055	0.042	0.031	0.02	0.015	0.01	0.0064	0.0046	0.004
	RMSE	0.234	0.206	0.178	0.1504	0.124	0.1	0.079	0.0678	0.067
	AMBE	0.122	0.107	0.092	0.077	0.062	0.049	0.037	0.0313	0.031
	PSNR	60.713	61.84	63.12	64.57	66.25	68.12	70.083	71.5048	71.49

Table I shows the result for MSE, RMSE, AMBE and PSNR of Barbara.

Figure 2: Visual quality results for Barbara image,(a)Original Image (b) Corrupted Image with salt and pepper noise with standard deviation 40(c)Proposed method with n=2 (d)Proposed method with n=3 (e)Proposed method with n=4 (f)Proposed method with n=5 (g)Proposed method with n=6(h) Proposed method with n=7 (i)Proposed method with n=8(j) Proposed method with n=9 (k) Proposed method with n=10.

Image	Metric	HE	n=5	n=6
Pepper	MSE	0.0612	0.0242	0.0164
	RMSC	0.2475	0.1557	0.1282
	AMBE	0.128	0.0811	0.0656
	PSNR	60.2617	64.2937	65.9701

Table 2: shows the result for MSE, RMSC, AMBE and PSNR of Pepper Image.

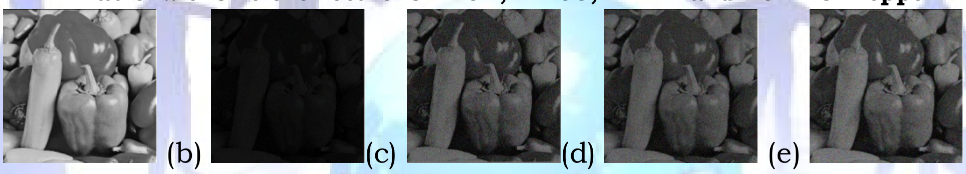

Figure 3: Visual quality results for Pepper image.(a)Original Image(b)image corrupted with salt and pepper noise with standard deviation 30(c) Output obtained after Histogram Equalization(d) Proposed method n=5(e) Proposed method n=6

Table 1& 2 shows the result of average values for AMBE, PSNR, and RMSC after applying on 25 standard images. It is clear from table 1 & 2 that the proposed method is able to enhance the contrast without affecting the mean brightness of the input image. Also PSNR values are slightly larger than HE method. This shows that the enhanced image is similar to the input image, i.e., all the finer detail of the image preserved in the output image. We can also verify it by visual inspection of the figure1& 2(both Barbara and Pepper image), that the proposed method we are able to enhance the contrast of the image without losing any of the details. Moreover all the values of AMBE are also small which shows that mean brightness of input and output are almost equal.

5 Simulation Results

Previous algorithms and the proposed algorithm are simulated on several images .Histogram equalization enhances the contrast of the dark objects while it deemphasizes the contrast of the background and smaller regions. Proposed Method produce enhanced results.

These results are simulated on 256*256 input images and on 512*512. Using this method, the contrast of the background is drastically enhanced compared with histogram equalization.

6 Conclusions

In this paper, we proposed a new brightness preserving contrast enhancement method as well as noise filtering method based on extended Fast Fourier transform function; in this method we are multiplying every pixel by that enhancement factor. Moreover it takes less time for computation and need fewer calculations, which improve the overall dynamic appearance of an image.
Proposed method was tested on different standard gray scale images or quantitative and subjective enhancement performance of proposed method was evaluated and compared to other contrast enhancement techniques for gray scale images. The simulation results demonstrated that proposed method gives better results in comparison of other methods. Proposed method can be implemented easily in the real time system and can be successfully used in various applications suffering from different image contrast problems and image corrupted with various noises. It is more effective and much faster compared to other method. This method achieves drastically low computation overhead compared to other methods.

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