# Median Filter Driven Approach for Contrast Enhancement of Ultrasound Images: A Technical Note

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***Abstract -*** Contrast is the rate of change of level of intensities between the neighboring pixels. It is the difference which allows the visual capability to distinguish the background and foreground of an image. It is one of the important parameter needs to be considered for the low contrast images specifically in the medical field. A procedure for contrast enhancement of the medical images is demonstrated in the paper. This approach accomplishes a median filter driven CLAHE contrast enhancement technique. This technique is practically implemented on the medical images and the performance parameters have been calculated for the evaluation purpose of framed approach.

**Keywords-** contrast; low contrast images; contrast enhancement; CLAHE; median filter; medical images.

## I. INTRODUCTION

The contrast enhancement is one of the necessary requirement for images to be visually better interpreted and of higher perpetual quality. There have been many reasons [1] for the low grade images. The contrast is defined as the visual difference between the image and its objects that makes the image more understandable and distinguishable. There have been many methods in this context, while the contrast enhancement and the variation filtering are in concern to solve the contrast related problems. The contrast enhancement [2] decreases pixel variation among homogeneous regions present in any image. This approach is in the context of contrast enhancement using histogram equalization method along with the median filter towards the goal to improve the quality of an original image. However, it is necessary to preserve the edge information and smoothening the noisy signals present in any image. Median filtering is one of the smoothing techniques [2] known in the field of image processing. The paper is organized as: Section 2 describes the image enhancement with spatial domain and frequency domain techniques. In section 3 Histogram Equalization is discussed and section 4 describes median filtering method. Section 5 contains the materials and methods used in the work with conclusion described in section 6.

## II. IMAGE ENHANCEMENT

This technique tends to improve the quality of the image in the context of its brightness, contrast, noise removal or its sharpening. The image enhancement has been one of the most appealing areas among different digital image processing methods utilized for better viewing of any digital image. The Image enhancement techniques are defined under two categories spatial domain and frequency domain.

### *A. Spatial Domain Technique*

The Spatial Domain Technique deals with the image plane and the direct pixel manipulation [3], it refers to the aggregation of all image composing pixels, which directly operate on the pixels of an image.

The spatial domain technique is given by:

$$S(x,y) = H(f(x, y)) \quad (1)$$

Where, f(x, y) is an input image, with H as an operator and S(x, y) denotes the operator on f(x, y).

### *B. Frequency Domain Technique*

The frequency domain technique refers to the modification of Fourier Transform of the image [3]. The steps in frequency domain technique include calculation of Fourier transform, filtering and inverse Fourier Transform.

## III. HISTOGRAM EQUALIZATION

Histogram Equalization deals with the improvement of an image by making adjustment in the image histogram, through widening of the peaks and compressing the valleys [4]. It spreads out the intensity values in order to achieve the contrast of an image. The method transforms the gray level of the image on the basis of the probability of occurrence of the gray levels in the input image. Histogram Equalization is a simple and straight forward technique that can even recover the original histogram of the image [5, 33].

Histogram Equalization increases the global contrast of an image, which can be described as:

If an image, I(x, y) is an image with D discrete levels then,

$$I(x, y) = \{I_o, 1\ldots\} \quad (2)$$

And the probability density function, of an image I(x, y) is given by-

$$p(I_k) = n_k / n \quad (3)$$

Where k = 0, 1…-1 with n as the total no. of samples present in an input image and $(I_k)$ is the representation of no. of pixels with same intensity as $I_k$ [1].

The Histogram equalization is the technique in which the input image is mapped onto the dynamic range of the image by using a cumulative density function, which is described as:

$$C(x) = \sum_{i=0}^{k} p(I\ k), \text{ where } I_k = x \text{ for } k = 0, 1 \ldots L-1 \quad (4)$$

### A. Disadvantages of Histogram Equalization

The disadvantages of Histogram Equalization are as follows:

1) The Histogram Equalization method may sometimes result into over enhancement of the image, due to the high stretching of gray levels.
2) The method, did not consider the mean brightness of an image.
3) The method, sometimes cause undesirable artifacts.

### B. Variations of Histogram Equalization

Variations in Histogram Equalization are further divided into two categories:

#### 1) Global Enhancement Techniques

There are several exiting Histogram Equalization methods known for digital image processing [6]. The traditional Histogram Equalization, also known as Global Histogram Equalization is a method that uses the information of all the intensities present in the image with the goal of uniform redistribution of the image intensity over the complete range of grey levels [6]. In [7] the researchers have shown that the Histogram Equalization sparsely distributes the grey level of the image and thus improves the contrast. Bi- Histogram Equalization method [8] that divides the histogram of an image into two sub- histograms, this method has the capability to more preserve the brightness of an image. BPBHE, known as Brightness Preserving Bi- Histogram Equalization, this method tends to preserve the brightness of an image. DSIHE means Dualistic Sub- Image Histogram Equalization method; it uses median value to separate the histogram instead of mean value. MMBEBHE, called as Minimum Mean Brightness Error Bi Histogram Equalization Method, this method is also called as the extended method of Brightness Preserving BHE, it has shown a better level of enhancement and preservation leading to natural enhancement [8]. BPDHE, called as Brightness Preserving Dynamic Histogram Equalization method tends to preserve the mean brightness along with equalizing the intensity values of input and output images [9]. BPDHE is also called as the advanced version of Histogram Equalization method; it divides the image histogram into several sub histograms and assures that there is no dominating segment lying in any newly formed sub- histograms [10].

#### 2) Local Enhancement Techniques

The local enhancement techniques are known for enhancing the overall contrast of the images and even more effectively than global enhancement techniques [10]. The Local Enhancement techniques include AHE and CLAHE.

##### a) AHE

AHE is defined as Adaptive Histogram Equalization method; it is the method that deals with the processing of several histograms, with each histogram corresponding to the different portion of an image and is used in re- arranging the image with its brightness values [11, 12]. Histogram Equalization has been an easiest and one of the appropriate techniques being used for the Contrast Enhancement [13].

##### b) CLAHE

CLAHE is described as Contrast Limited Adaptive Histogram Equalization, it is the method of Contrast enhancement, in which the histogram is clipped off at a threshold value and then equalization is done [14]. The CLAHE method is applied on the small regions of the image called as tiles. The method is controlled by two main parameters, that is, clip limits and blocks size that is controlled. As the value of clip limit increases, the image brightness also tends to increase similarly, as the block size increases, the value of image contrast also increases. Thus, CLAHE is called as one of the established method for image enhancement [15, 16].

## IV. MEDIAN FILTERING

The Median Filtering method calculates the median of the input image. If an image consists of odd no. of elements, then the middle element is itself is a Median. However, for SFM (Standard Filtering Method), a window moves through the sample values of an image and the median is calculated for each position. This median is written at the output place pixel value of the same position as a centre element. This is called as the running median [17].

The median filtering has produced better noise reduction, with very less amount of image blurring. The method is found effective even with the presence of unipolar and bipolar impulsive noise [3].

The proposed approach uses, the application of median filtering method along with histogram equalization for the better visualization of medical images.

## V. MATERIALS AND METHODS

The experimental procedure has been carried out on the medical ultrasound images, particularly of gallbladder images having stones. The images of the patients suffering from gallstones have been taken and processed as follows.

Medical Ultrasonography is a renowned non invasive and diagnostic tool in medical imaging [33, 34]. It is a real time inexpensive procedure utilized to view internal body parts by transmitting the sound pulses of high frequency between (1- 20 MHz)[17].These waves travel inside the body through bones, soft tissues and the tissue fluid. Later on, they are reflected back and are picked up by the probe for processing in the computer. Speckle noise is one of the commonest noises found in the ultrasound image [18]. Thus, using image enhancement methods has become more important [19] [20] for the processing of medical images.

A sample ultrasound image of Gallstone is chosen, as shown in Figure 1

Figure 1 A sample image

The corresponding Histogram of the image is shown in Figure 2. In the proposed method, the initial contrast is set to 0.30 and brightness is set to 0.50. The histograms of the original image and transformed image (with set contrast and brightness) are calculated and thus displayed. The histogram displays the value of input intensity versus output intensity of the images with contrast enhancement [29, 30, and 31].

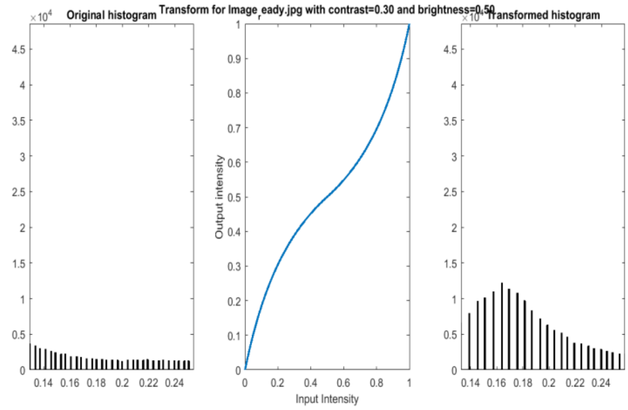


Figure 2 Input Histogram and transformed Histogram

Then Contrast Limited Adaptive Histogram Equalization (CLAHE) procedure using global thresholding method is applied to the input images. The Figure 3 shows the Ultrasound image with the application of CLAHE technique.

Figure 3 CLAHE application

After that, a standard median filter is applied on the histogram equalized image. Figure 4 shows the result of median filtering.

Figure 4 Median filtered image

For the purpose of performance Evaluation at each level of the procedure is done, the following parameters have been calculated.

### A. *Standard Deviation*

Standard deviation is a measurement of diversity or the statistics variation [21, 22]. It is one of the dispersion parameters. The lower is the value of standard deviation; it means that the data points are near about the mean values and the higher value of standard deviation indicate that the data points are quite widely spread. The expression for standard deviation is given as-

$$S.D\ (j, k) = \sqrt{\frac{1}{pq-1}}\sum_{(r,c)\in H}\left[g(r,c) - \frac{1}{xy-1}\sum_{(r,c)\in H} g(r,c)\right]^2 \quad (5)$$

### B. *Entropy*

The entropy of any image is described as the amount of information in the image. The amount of entropy [23, 24] is less for darker part of the images and the image having zero entropy value are known as flat images. Entropy is given as:

$$E = -\sum_j Pj\ log_2\ P_j \quad (6)$$

Where, $P_j$ is the value of probability of difference of any two neighboring pixels.

### C. *Contrast*

The physical contrast of any image is defined as the patch of light seen on the dark background [25]. The contrast is a basic perpetual attribute for an image, and the contrast sensitivity is defined as a function of spatial frequency content of an image [26].

### D. *Energy*

The Energy of any image is described as the absolute difference between the image intensities in the x and y directions. This energy is also called as the External Energy.

*E. Homogeneity*

The Homogeneity is defined as the uniformity in textural features of an image [27, 28].

The median filter driven approach for contrast enhancement is implemented on the medical ultrasound images and the evaluated performance graphs at each level of processing are shown as: the original image evaluated performance graph in Figure 5, histogram equalized image evaluated performance graph in Figure 6, and the median filtered image evaluated performance graph in Figure7.

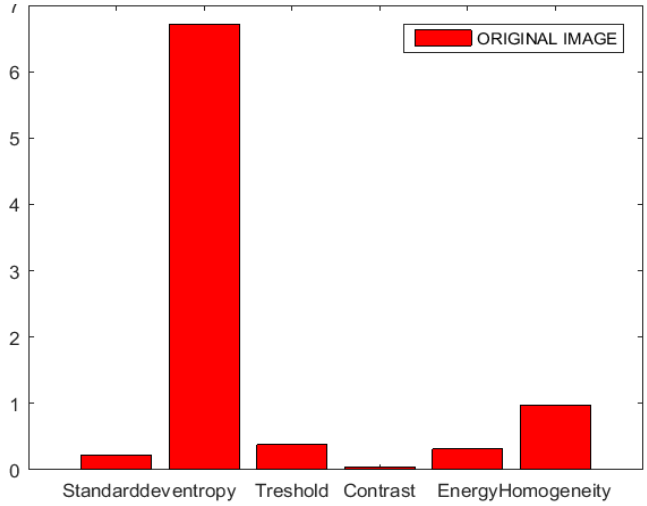


Figure 5Evaluated graph of an original image

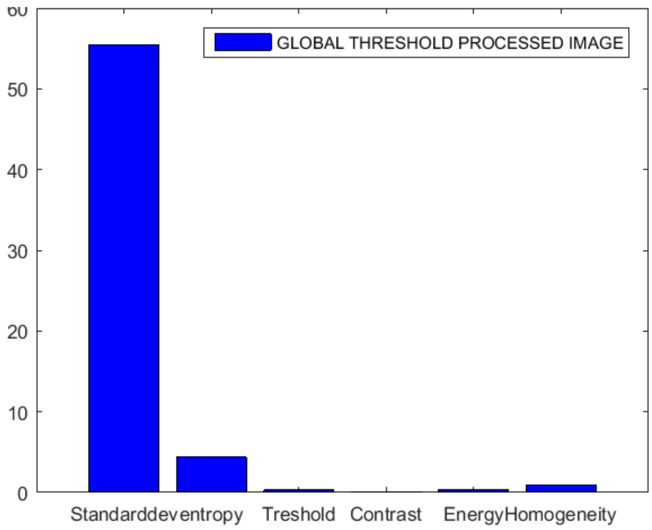


Figure 6 Evalted graph of Histogram equalized image

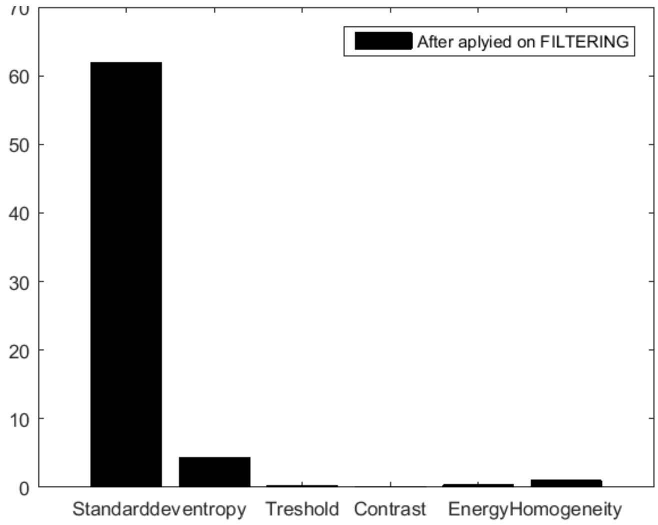


Figure7 Evaluated graph of Median filtered image

For the purpose of comparison, the values of Standard Deviation, Entropy, Threshold, Contrast and Homogeneity are stated as in Table 1.

Table**1** Comparison of the parameters for the original image, CLAHE processed image and after Median filtered image.

| **Parameter of Comparison** | **Original image** | **CLAHE processed image** | **Median Filtered image** |
|---|---|---|---|
| **Standard dev.** | 0.215125 | 52.366531 | 59.166352 |
| **Entropy** | 6.798308 | 4.339738 | 4.286172 |
| **Threshold** | 0.368627 | 0.282353 | 0.321569 |
| **Contrast** | 0.047191 | 0.077340 | 0.047339 |
| **Energy** | 0.293665 | 0.367373 | 0.350867 |
| **Homogeneity** | 0.976582 | 0.974370 | 0.982524 |

## VI. CONCLUSION

The application of the contrast enhancement approach driven through a median filter has shown a drastic change in the values of Standard Deviation, with almost no change in the homogeneity level of image between the regions of the image. However, the entropy values have shown an effective decrease that leads to the rejection of information less portions of the image. And also the strategy has shown a very small effect on the contrast of the image. This is an ongoing research, which is still being worked on for different levels of contrast and brightness of an image.

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