Medical Image enhancement using BPDHE with high Boost Filter

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Abstract- *In medical image processing, low contrast image analysis is a challenging problem. Low contrast digital images reduce the ability of observer in analyzing the image. The most effective method used for contrast enhancement is Histogram Equalization (HE). Here we propose a new method named "Brightness Preserving Dynamic Histogram Equalization Contrast Enhancement with high boost filtering" (HBF-BPDHE) for medical images. This method uses two step processing, in first step global contrast of image is enhanced using Dynamic histogram equalization followed by brightness preserving concept and then in second step high boost filtering is used for image sharpening, this filtering is apply after image normalization. To evaluate the effectiveness of our method we choose two widely used metrics Absolute Mean Brightness Error (AMBE) and Entropy. Based on results of these two metrics this algorithm is proved as a flexible and effective way for medical image enhancement and can be used as a pre-processing step for medical image understanding and analysis.*

Keywords:- High Boost Filter, Medical Image Enhancement, Histogram Equalization, Contrast Enhancement, AMBE, Entropy.

I. INTRODUCTION

In digital image processing contrast enhancement techniques are an important techniques for both human and computer vision. Histogram Equalization (HE) is one of the simplest and effective technique to perform contrast enhancement. In histogram equalization we reduce the number of gray levels by combining two or more less frequent neighboring gray levels (having small probabilities) in one gray level; also we stretch high frequent intensities over high range of gray levels to achieve comparatively more flat histogram. This flattering causes the overall enhancement of contrast of the input image. In histogram equalization we do not have any mechanism to control the enhancement level, due to this sometime output image have over enhanced regions.

Also HE could not effectively work, when the input image contains regions that are significantly darker or brighter than other parts of the image. To overcome above mentioned limitations of the traditional HE method and make it more flexible, a number of HE based methods proposed by various groups of researchers. One of the most significant contributions in this line was Adaptive Histogram Equalization proposed by Hummel [1], Ketcham [2]. In this method, authors proposed that each pixel should be mapped to intensity proportional to its rank in the pixels surrounding it. AHE has produced excellent results in enhancing the signal component of an image but in many cases it enhances noise too. Noise enhancement introduces the artifacts in the output image and theses artifact reduces the ability of observer to detect information contained in the image. K. Zuiderveld [3] introduces a new and effective tool named Contrast Limited Adaptive Histogram Equalization (CLAHE), designed to deal with these artifacts in the output image. Later various researcher proposed variants of CLAHE, few of them were discussed in [4], [5], [6]. Another interesting technique proposed by Polesel et al., [7], Adaptive Unsharp Masking (US) technique. This technique is effective but in certain cases for example in medical images it is unable to detect low contrast edges present in images. All the above mentioned methods improve image contrast but they have a common drawback that they are not able to preserve image brightness.

Tarun Kumar Agarwal et.al. [8] proposed a new method named "Modified Histogram Based Contrast Enhancement using Homomorphic Filtering" (MH-FIL) for medical images. In their method, they initially modify the histogram of input image using a histogram modification function and then they apply HE method for contrast enhancement on this modified histogram. After that we use homomorphic filtering for image sharpening and then to minimize the difference between input and processed image mean brightness, they normalize it.

Here we propose a new method named "Medical Image enhancement using BPDHE with high Boost Filter" (HBF- BPDHE) for medical images. In proposed method, firstly global contrast of image is enhanced using Dynamic histogram equalization followed by brightness preservation and then high boost filtering is used for image sharpening. The rest of this paper is organized as follows. Section II briefly covers the histogram molding method. Section III describes in detail the proposed method HBF-BPDHE. Quality parameters are given in section IV. Some experimental results are shown in Section V and a short concluding remark is given in Section VI.

II. HISTOGRAM MODELING

Intensity transformation functions based on information extracted from image intensity histograms vital role in image processing, in areas such as enhancement, compression, segmentation, and description. This section is on obtaining, plotting, and using histograms for image enhancement.

A. Image Histograms

The histogram of a digital image with L total possible intensity levels in the range [0, G] is defined as the discrete function $h(r_k) = n_k$ where r_k is the kth intensity level in the interval [0, G] and n_k is the number of pixels in the image whose intensity level is r_k. Often, it is useful to work with normalized histograms, obtained simply by dividing all elements of $h(r_k)$ by the total number of pixels in the image, which denote by n:

$p(r_k) = h(r_k) / n = n_k / n$ for k = 1,2, …., L from basic probability, recognize $p(r_k)$ as an element of the probability of occurrence of intensity level r_k.

B. Histogram Equalization Method

The histogram of an image is the graphical representation of the relative frequencies of the different gray levels in the image. It provides a total description of the appearance of an image. There are several contrast enhancement techniques based on histogram are available in order to improve the visible quality of an image. The most common approach is the histogram equalization. Histogram equalization is a preprocessing technique to enhance contrast in all type of images. Equalization implies mapping from given intensity distribution (the given histogram) to uniform intensity distribution (a wider and more flat distribution of intensity values) so the intensity values are spread over the whole range. Through this adjustment, we can achieve close to equally distributed intensities in an output image.

In histogram equalization we consider an image as a 2 dimensional array of gray levels. Suppose input image *f(x, y)* composed of discrete gray levels in the dynamic range [0, *L*-1] then the transformation function $C(r_k)$ is defined as:

$$C(r_k) = \sum_{i=0}^{k} p(r_i) = \sum_{i=0}^{k} \frac{n_i}{n}$$

Where $0 \le C(r_k) \le 1$ and k = 0, 1, 2….L-1. In equation (1), n_i represents the number of pixels having gray level ri, n is the total number of pixels in the input image, and $P(r_i)$ represents as the Probability Density Function (PDF) of the input gray level ri. Based on the PDF, the Cumulative Density Function (CDF) is defined as $C(r_k)$. This mapping in (1) is called Histogram Equalization (HE) or Histogram Linearization.

Here $C(r_k)$ can easily be mapped to the dynamic range of [0, L-1] multiplying it by (L-1).

III. BRIGHTNESS PRESERVING DYNAMIC HISTOGRAM EQUALIZATION WITH HIGH BOOST FILTER

In this section we will completely describe proposed method based on brightness preserving dynamic histogram equalization with high boost filter (HBF-BPDHE). Our method has two step processing, in first step global contrast of image is enhanced using BPDHE then in second step High boost filtering is used for image sharpening, Figure 1 shows block diagram of proposed method.

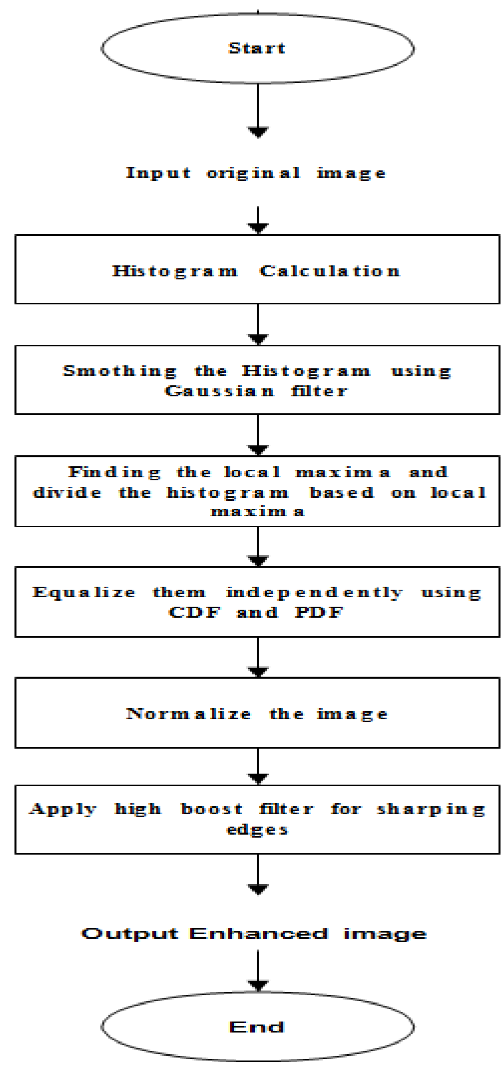


Fig. 1. Flow chart of proposed HBF-BPDHE method

A. Contrast Enhancement by BPDHE

The Brightness Preserving Dynamic Histogram Equalization (BPDHE) introduced by Nicholas sia pik Kong et al (2008) is the enhanced version of the DHE that can produce the output image with the mean intensity almost same as that of the input image it completes the requirement of preserving the mean brightness of the image. It consist of several steps. They are:

The first step is the image smoothing. The histogram is smoothed by using one dimensional Gaussian filter. This function removes the redundant and noisy maximum and minimum peaks from the image histogram. This removal smoothes the image histogram's jagged points which are generated by high frequency components of the image. The jagged shape of the image histogram is caused mainly by noise. The Gaussian filter used for smoothness is defined in equation 2.

$$G(x) = e^{-(x^2/2\sigma^2)}$$

The second step finds *the local maximum* points of the histogram by tracing the histogram of the smoothed version of the image. A point on the histogram is a local maximum if its amplitude is more than its neighbors. Next the image histogram is partitioned according to the found maximum points. Each interval is the distance between two successive local maxima. Each partition will be assigned a new dynamic range by:

$$span_i = high_i - low_i$$

$$factor_i = span_i \times \log_{10} M$$

$$range_i = (L-1) \times factor \,/ \sum_{k=1}^{n+1} factor_k$$

where $high_i$ is the highest intensity value contained in the sub histogram ; low_i is the lowest intensity value; M is total pixels.

Step third is HE. This step equalizes the histogram of each interval separately. The transfer function is:

$$y(x) \quad start_i \quad (end_i \quad start_i) \sum_{k=start_i}^{x} \frac{n_k}{M}$$

The final step of this method involves the normalization of the output intensity by approximates the mean of the input image to the output one, by multiplying the intensity of each pixel to the ration of the mean intensity of the input and the output one. So, the average intensity of the resultant image will be same as the input. With this criterion, BPDHE will produce better enhancement compared with CLAHE, and better in preserving the mean brightness compared with DHE [9].

The transform function of brightness normalization is defined by:

$$g(x, y) = (M_i \,/\, M_o) f(x, y)$$

Where g(x, y) is the final output image and f(x, y) is the output just after the equalization.

Now after applying above mentioned method, it produces images with better contrast enhancement in terms of both subjective and objective as compared to other medical image enhancement methods.

B. Image sharping using High Boost Filter

Next we are applying high boost filtering to enhance the edges of histogram equalized image. High boost filter is a popular method that allows sharpening in high detail areas but little or no sharpening in flat or smooth areas.

A high boost filter is also known as a high frequency emphasis filter. A high boost filter is used to retain some of the low-frequency components to and in the interpretation of a image.

In high boost filtering the input image *f(m,n)* is multiplied by an amplification factor *A* before subtracting the low pass image are discuss as follows.

High boost =A × f(m,n) **-** *low pass*

Adding and subtracting 1 with the gain factor
High boost = A − 1 × *f(m,n)* + *f(m,n) -low pass*

But *f(m,n)* **-** *low pass= high pass*
Highboost= ***A* −1** × ***f(m,n)*** + *high pass*

IV. MEASUREMENT OF HISTOGRAM EQUALIZATION

Every above method are compared by statistical point of view by using some standard quality measures

A. Peak-signal-to-noise-ratio (PSNR):

PSNR is the evaluation standard of the reconstructed image quality, it is generally used in measuring the quality and it is important measurement feature. PSNR is measured in decibels (dB) and is given by [12]:

$$PSNR = 10 \log 255^2 / MSE$$

Where the value 255 is maximum possible value that can be attained by the image. MSE is Mean square error and it is defined as error between two images. Higher the PSNR value is, better there constructed image [10].

B. Entropy

Discrete entropy E(X) measures the richness of details in an output image after enhancement (5) [11].

$$E(p) = -\sum_{k=0}^{L-1} p(k) \log_2 p(k)$$

C. Contrast:

Contrast can be specified as ratio, such at 3:1. An N:1 ratio means that dividing the brighter luminance by the darker luminance gives a number that is equal to N. This can also be specified as an equation:

$$C_r = \frac{y_{max}}{y_{min}}$$

For display systems, contrast relations are white: black and highly magnified by neglecting the impact of ambient illumination in usual viewing environments [10].

D. Absolute mean brightness error (AMBE):

Absolute Mean Brightness Error is used to assess the degree of brightness preservation .It is calculated using the equation as [11].

$$AMBE = \left| E(x) - E(y) \right|$$

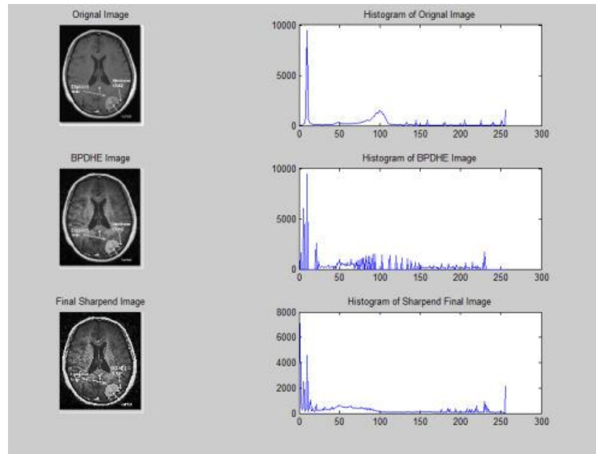
Where, E(x) is the mean of the input image, E(y) is the mean of the output image. A median value implies better brightness preservation [10].

V. ANALYSIS OF EXPERIMENTS AND RESULTS

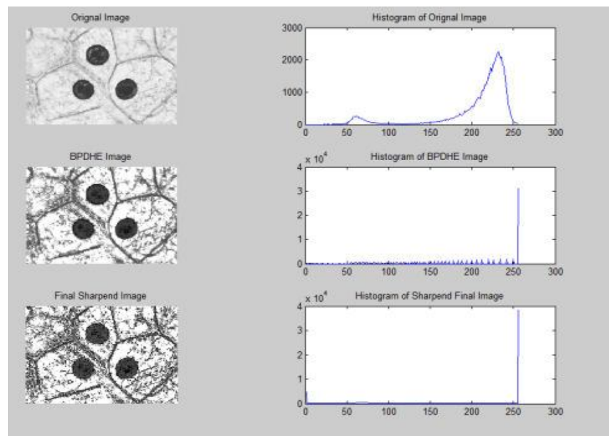
In this section, we demonstrate the performance of the proposed method HBF-BPDHE in comparison with some existing HE based contrast enhancement methods, like HE, CLAHE and MH-FIL.

A. Simulation Result

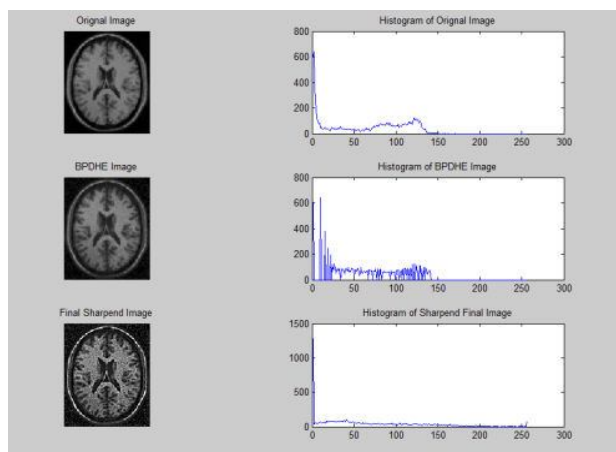
In the following figure 2, we have shown contrast enhancement by proposed HBF-BPDHE methods on different images.



(a)



(b)



(c)

Fig. 2. shows results produced by HBF-BPDHE method on a mammogram image patch.

B. Image Quality Analysis

We are showing results for 10 medical images, these images include mias mammogram images and images are provided online at [11].

The following, Table I shows results of Absolute Mean Brightness Error (AMBE) of proposed HBF-BPDHE with comparison to other methods.

Table I. Absolute Mean Brightness Error (AMBE)

Image Name	HE	CLAHE	HM-FIL	HBF-BPDHE
mdb143	5.20	7.07	7.13	1.33
mdb144	5.46	7.23	7.26	0.17
mdb145	4.44	5.96	5.52	0.42
mdb146	4.34	5.94	5.48	0.36
mdb147	5.40	7.21	7.21	0.91
mdb148	5.30	7.20	7.12	0.26
headCT-Vandy	2.96	4.11	3.87	2.92
chest-xray-vandy	5.13	7.04	6.81	0.05
MRI-of-knee-Univ-Mich	5.15	7.19	6.96	1.64
MRI-spine1-Vandy	4.45	6.57	5.81	1.57
Average	**4.78**	**6.55**	**6.32**	**0.96**

Based on results of Table I, we observe that MH-FIL has least values in all 10 images as compare to other methods. Further if we look at last row of Table I, which shows average results of AMBE then we find then MH-FIL has least average AMBE values among other methods.

Table II shows results of entropy values on given images by different methods.

Table II. Entropy

Image Name	HE	CLAHE	HM-FIL	HBF-BPDHE
mdb143	54.695	6.959	0.005	0.89
mdb144	46.798	8.376	0.000	0.08
mdb145	77.711	4.654	0.013	0.34
mdb146	80.608	4.607	0.049	0.31
mdb147	50.405	6.873	0.008	0.14
mdb148	68.119	8.512	0.000	0.32
headCT-Vandy	85.757	0.660	0.042	0.38
chest-xray-vandy	8.521	20.059	0.077	0.39
MRI-of-knee-Univ-Mich	12.759	14.318	0.040	0.24
MRI-spine1-Vandy	61.084	7.817	0.048	0.03
Average	**54.646**	**8.283**	**0.028**	**0.31**

Based on results of Table II, a careful examination of the entropy values reveals that our method produces comparatively better average entropy values from that of HE and MH-FIL.

VI. CONCLUSION

The HBF-BPDHE method provides optimum contrast enhancement while preserving the brightness of given medical image and suitable for all types of medical images. We used Miasmammogram images and low-dose CT images for comparing our method with the existing other methods. Experimental results show that AMBE of the proposed method is less in comparison of other methods. Also entropy of the proposed method is better from HE,MH-FIL, and is comparative with the CLAHE. On the basis of analysis of these two metrics shows that HBF-BPDHE preserves the input image brightness more accurately and gives processed image with better contrast enhancement

REFERENCES

[1] RA Hummel, "Image Enhancement by Histogram Transformation,Computer Graphics Image Processing," (1997), vol. 6, pp. 184-195.

[2] DJ Ketchem, Lowe RW and Weber JW, "Real Time Image Enhancement Techniques, in Seminar on Image Processing," Hughes Aircraft, Pacific Grove, California, (1976), pp. 1-6.

[3] K Zuiderveld, "Contrast Limited Adaptive Histogram Equalization," Chapter VIII, Graphics Gems IV, P.S. Heckbert (Eds.), Cambridge, MA, Academic Press, (1994), pp. 474-485

[4] A.M. Reza, "Realization of the Contrast Limited Adaptive Histogram Equalization (CLAHE) for Real-Time Image Enhancement", Journal of VLSI Signal Processing, (2004) , vol.38, pp. 35-44.

[5] A Toet, "Adaptive Multi-Scale Contrast Enhancement through Non- Linear Pyramind Recombition", Pattern Recognition Letters, (1990), vol. 11, pp. 735-742.

[6] S Arigela and V.K. Asari, "Adaptive and Nonlinear Technique for Visibility Improvement of Hazy Images", Proceedings of the 7th international conference on Advances in visual computing, (2011), vol. 2, pp. 75-84.

[7] A. Polesel, G Ramponi and V. J. Mathews, Image Enhancement via adaptive unsharp masking, IEEE Transaction on Image Processing, 9 (2000), pp. 505-510.

[8] Tarun Kumar Agarwal, Mayank Tiwari, Subir Singh Lamba,"Modified Histogram Based Contrast Enhancement using Homomorphic Filtering for Medical Images",IEEE Conference 2014 .

[9] Rajesh Kumar, Harish Sharma, Suman, "Comparative study of CLAHE, DSIHE & DHE schemes", International Journal of Research in Management, Science & Technology, Vol.1, No. 1.

[10] Rajesh Garg, Bhawna Mittal, Sheetal Garg, "Histogram equalization techniques for image enhancement ", IJECT Vol. 2, Issue 1, March 2011.

[11] Medical Images Database, http://www.imageprocessingplace.com/DIP3E/dip3e_book_images_downloads.html.