2019 29th International Conference on Computer Theory and Applications (ICCTA) | 978-1-7281-5276-9/20/$31.00 ©2019 IEEE | DOI: 10.1109/ICCTA48790.2019.9478834

X-Ray Image Enhancement using Global Histogram Equalization

Muhammad Hameed Siddiqi

College of Computer and Information Sciences, Jouf University, Sakaka, Aljouf, Kingdom of Saudi Arabia
mhsiddiqi@ju.edu.sa

Abstract— **Over the last decade, medical image processing has emerged as an important research area because it is very much sensitive to the naturalistic environments. The principle objective of the image enhancement is to recover the features of the input image. Some factors which make the image enhancement a challenging task. For instance, fluctuation of environmental factors in both training and testing images; and accurate enhancement of the images is required before diagnosis the disease in medical field. Existing methods cause over-amplifying, and occasionally it yields checkerboards of the improved image due to which we may lose the important information in the X-ray image. Therefore, this work implements a simple guideline in order to build small application for medical image enhancement using global histogram equalization that is the enhanced version of histogram equalization technique, which improves the image quality by enlarging the vigorous assortment of the intensity by the histogram of the entire image. The method was tested on publicly available X-ray dataset. The average recognition rate across the dataset specifies the achievement of utilizing the proposed method for image enhancement.**

Keywords—Medical imaging, global histogram equalization, X-rays.

I. INTRODUCTION

The image processing field is so diverse that some arrangement of organization is required in order to define the extensiveness of this field. One approach is to develop and understanding the scopes of image processing applications that classify images based on their visual sources such as X-ray. Nowadays, the main source of energy that used in these images is the electromagnetic energy spectrum like auditory, ultrasonic, and electronic microscopy. Artificial images generated by computer were employed for modeling and visualization [1].

X-ray image has a significant role in healthcare domain in order to help the doctors for identifying different types of diseases. In the past decades, particular methods were proposed for X-ray images enhancement; but the image enhancement augmented the noise or yield image distortion that is not recommended for disease diagnosis [2]. The authors of [3] proposed a center-to-boundary and boundary-to-boundary method in order to enhance the image using $n \times n$ mask; however, they used 3×3 mask for enhancement, which loses lots of information. Similarly, two-stage filtering and contrast enhancement based technique was proposed by [4] for X-ray images enhancement. They integrated two filters such as adaptive median filter and bilateral filter to diminish the mixed noise (like comprises Gaussian noise and imprudent noise); whereas conserving the edges that are essential structures in the images. Then the image has been enhanced by utilizing gray level morphology and contrast limited histogram equalization (CLAHE). However, this method has a drawback of over-amplifying noise [5].

On the other hand, the authors of [6] integrated some well-known filters such as histogram equalization, local histogram equalization, brightness preserving bi-histogram equalization, and dualistic sub-image histogram equalization followed by median filter. However, this method produces artifacts and time consuming in real world domain such as in healthcare. In addition, extra computation time is required in order to sort the intensity value of each set [7]

Likewise, the authors of [8–11] employed wavelet domain homomorphic filter and CLAHE. However, wavelet transform is computationally much expensive. Furthermore, computational wise, the discrete wavelet transform is much expensive. It also took certain vitality in order to capitalize in wavelets to make it able for choosing the proper ones for an explicit purpose, and for correctly implementation [12]. Similarly, another frequency domain filter such as the homomorphic filter has been applied for X-ray image enhancement; however, this filter still has the drawback of gray scope amendments, due which this technique is called grey correction technique. On the other hand, we choose different features and requirements for diverse images such as $H(u,v)$ in order to attain significant results. Commonly, pure homostasis filter does not has the capability to eliminate the noise presented in high frequency domain. Moreover, certain image processing filtration are done by employing some well-known filters like low-pass filter, high-pass filter, and homostasis filter for the purpose of X-ray image enhancement that can get good results. However, this filter different transformation function parameters are employed for the entire grip [13].

The authors of [14] proposed an integrated method for X-ray image enhancement. In which they highlighted the effect of spatial filtering coupled with smoothing and sharpening on radiological X-ray image, due to which the decision can be taken for applying the proper spatial filtering method in order to enhance the image. Moreover, they have presented the visual representation of an image for which they tried to calculate MSE and PSNR values to get the performance parameters for before and after the resultant image. However, these methods commonly lacks in providing satisfactory robustness and imperceptibility requirements [15].

Therefore, an appropriate technique for noise removal and enhancement is required. Therefore, for this purpose, we have proposed a method, which recovers the superiority of the image by enlarging the vigorous intensity range against the histogram of the entire image. It attains the balance parameter from the standardized collective dispersal of the illumination dispersal of the original image and reproduces this balance parameter through original image in order to restructure the intensity [16]. Global histogram equalization (GHE) determines the consecutively addition of the histogram values that further is standardized by dividing it through the entire number of pixels. Then the resultant value is multiplied by the highest value of the gray level that will be mapped against the preceding values based on one-to-one interaction scheme

Aforementioned, some related works about the enhancement have been discussed. The rest of the paper is organized as follows. Section II describes the outline of the proposed method for X-ray image enhancement. Section III provides experimental results with some discussions. Lastly, the paper is concluded in Section IV.

II. Methodology

The main purpose of the image augmentation methods are to highlight, sharpen and/or smooth the image features for demonstration and investigation. It facilitates the development of a resolution to a computer-imaging issue; therefore, we can employ the enhancement techniques for specific applications.

Suppose, the enhanced image is represented by *E(r, c)*, and input image *I (r, c)*. Application feedback is an important part of the process as shown in the following figures.

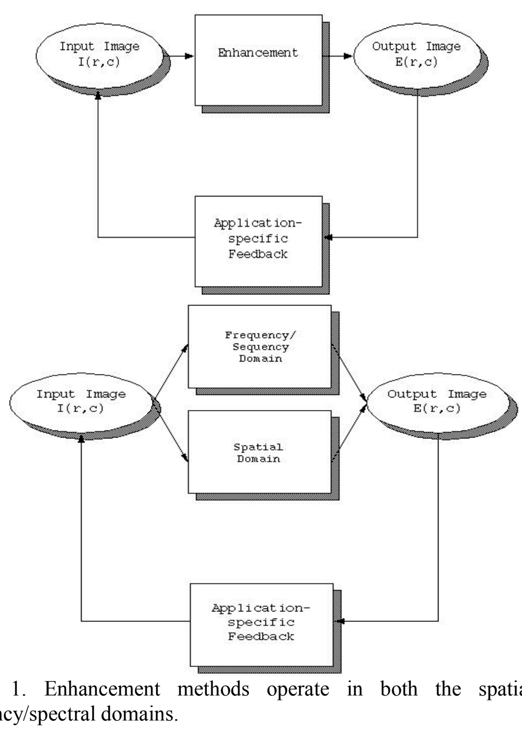

Figure 1. Enhancement methods operate in both the spatial and frequency/spectral domains.

A. Enhancement Method

Point Operations: Each pixel is modified by a calculation, which does not reliant on other values of the pixels.

Mask operations: The purpose of this operation is to modify each pixel based on the values presented in a small neighborhood (sub-image).

Global operations: In this operation, we consider all the values of the pixels in the entire image. On the other hand, spatial domain technique integrated all the three methods; while, the techniques in frequency domain take into account the global procedures.

Then the procedures in the frequency domain has a property as if it performs the transform on blocks of small image rather than utilizing the entire image. Due to this property, it becomes like “mask operations”. Enhancement techniques are used in both pre-processing (in order to ease the further imaging tasks), and in post processing (in order to create a more visibly required image). The method of enhancement itself might be used at the end to improve images for viewing.

B. Global Histogram Equalization (GHE)

Most of the medical images consisted of different resolutions and backgrounds that were captured against dynamic light conditions. The image enhancement is required in order to advance the images qualities. Therefore, for fast and easy processing, the background evidence, brightness clatter, and unwanted details are diminished. After this process, we get the sequence of images having standardized intensity, dimension and outline.

In the literature, there lots of methods, for example histogram equalization (HE) and local histogram equalization (LHE) have been proposed that diminished such types of environmental effects like brightness effects, noise, and illumination. However, these methods produces unnecessary relics and an exhausted look, because of this limitation it does not recommended for X-ray image enhancement [17]. Moreover, some time, these techniques produce over-enhancement and checkerboards on enhanced images [18]. Therefore, a novel method named global histogram equalization (GHE) has been employed to improve the image superiority.

Global histogram equalization recovers the superiority of the image by enlarging the vigorous intensity range against the histogram of the entire image. It attains the balance parameter from the standardized collective dispersal of the illumination dispersal of the original image and reproduces this balance parameter through original image in order to restructure the intensity [16]. Global histogram equalization (GHE) determines the consecutively addition of the histogram values that further is standardized by dividing it through the entire number of pixels. Then the resultant value is multiplied by the highest value of the gray level that will be mapped against the preceding values based on one-to-one interaction scheme.

Suppose, *I(x, y)* is an input image consisted of distinct gray levels within the vigorous range of $[0, L-1]$. The function of alteration is described as below:

$$S_k = T(r_k) = \sum_{p=0}^{k} P(r_p) = \sum_{p=0}^{k} \frac{n_p}{n} \qquad (1)$$

where $0 \le S_k \le 1$ and $k=0,1,2,\ldots,L-1$, n_p presents the entire number of pixels that have gray level r_p, n indicates the whole amount of pixels at the input image, and $P(r_p)$ shows the probability density function (PDF) of the r_p. To equally distribute the illuminated histograms of the image I, first the image has been normalized, and then the PDF of the given image I has been calculated as below:

$$P_i\left(I_k\right)=\frac{g_i}{n},0\leq I_k\leq 1 \text{ and} \sum_{k=0}^{L-1}P_i\left(I_k\right)=1 \qquad (2)$$

where n is the entire pixels of the input image, g_i is the position of the gray level in the image plan at *i-th* location, and I_k is the gray scale image. In the input gray level, the cumulative density function (CDF) is calculated based on PDF as described in $T(r_k)$ in (1). That conversion is called GHE, wherever S_k might be mapped against the vibrant collection of *[0, L – 1]* that is multiplied by *[L–1]*. The overall flowchart is shown in Figure. 2.

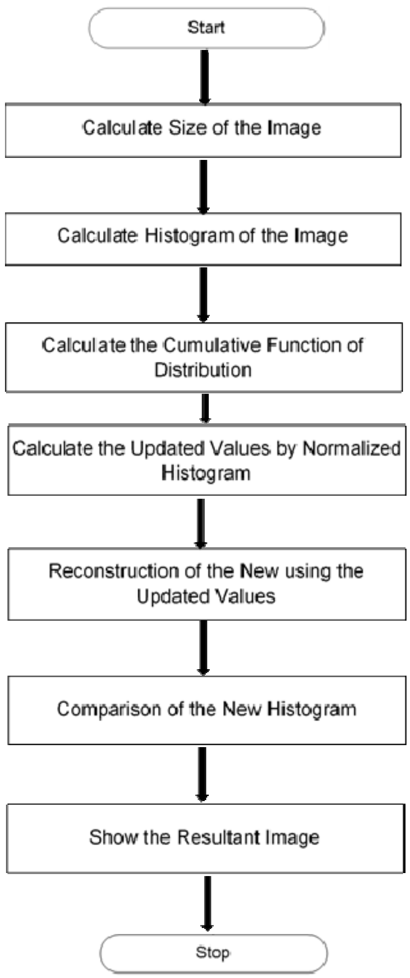

Figure 2. Flowchart for global histogram equalization.

III. Experimental Results and Discussion

The proposed method has been tested and validated on different medical images such as X-Ray images in order to check the significance of the developed method. These images were taken in dynamic noisy and dark environments. The overall results of the proposed method on different images along with existing works are presented in Figures 3, 4, and 5.

As can be seen from all the figures that the proposed method showed significant performance on different X-Ray images taken under dynamic noisy environments. This is because the proposed method recovers the superiority of the image by enlarging the vigorous intensity range against the histogram of the entire image. It attains the balance parameter from the standardized collective dispersal of the illumination dispersal of the original image and reproduces this balance parameter through original image in order to restructure the intensity. Global histogram equalization determines the consecutively addition of the histogram values that further is standardized by dividing it through the entire number of pixels. Then the resultant value is multiplied by the highest value of the gray level that will be mapped against the preceding values based on one-to-one interaction scheme.

IV. Conclusion

There are many old sources of electromagnetic radiations that are utilized for medical imaging. Among them, X-rays are most important and cheaper one, which is employed for different types of medical diagnosis. Most of the X-ray images were recorded under a very sensitive environment, which may contains the some environmental noise that could make the diagnosis very difficult.

Therefore, in this study, a technique has been proposed based on global histogram equalization in order to normalize the histograms of all the images. In this way, the system eliminates undesirable effects such as noise and lighting effects. This method reduces such noise by enlarging the vigorous intensity range against the histogram of the entire image. It attains the balance parameter from the standardized collective dispersal of the illumination dispersal of the original image and reproduces this balance parameter through original image in order to restructure the intensity. Global histogram equalization determines the consecutively addition of the histogram values that further is standardized by dividing it through the entire number of pixels. Then the resultant value is multiplied by the highest value of the gray level that will be mapped against the preceding values based on one-to-one interaction scheme. The proposed method outperforms against well-known existing works, such as histogram equalization and local histogram equalization that produce unwanted artifacts and washed-out images. Furthermore, the local histogram equalization produces over-enhancement and checkerboards of the enhanced image and that is one of the main limitations of the local histogram equalization. Therefore, several studies suggested avoiding the use of these methods. The proposed method has been tested and validated on publicly available standard dataset in order to check its performance. The proposed method showed a significant performance across the dataset, indicating the success of employing this method for X-ray image enhancement.

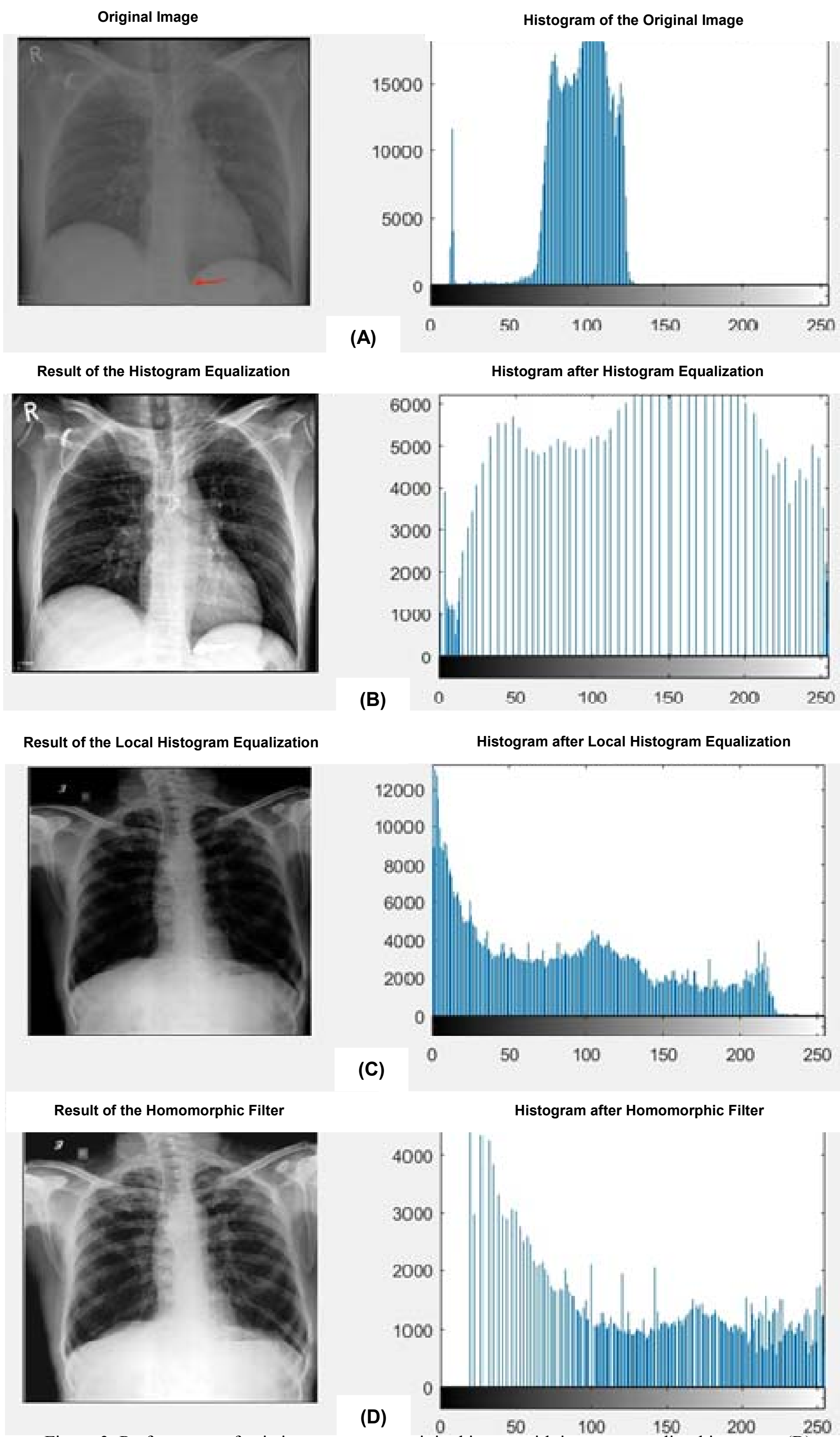

Figure 3. Performance of existing works, (A) Original image with its corresponding histogram, (B) Result of histogram equalization with its corresponding histogram, (C) Result of local histogram equalization with its corresponding histogram, and (D) Result of Homomorphic filter with its corresponding histogram

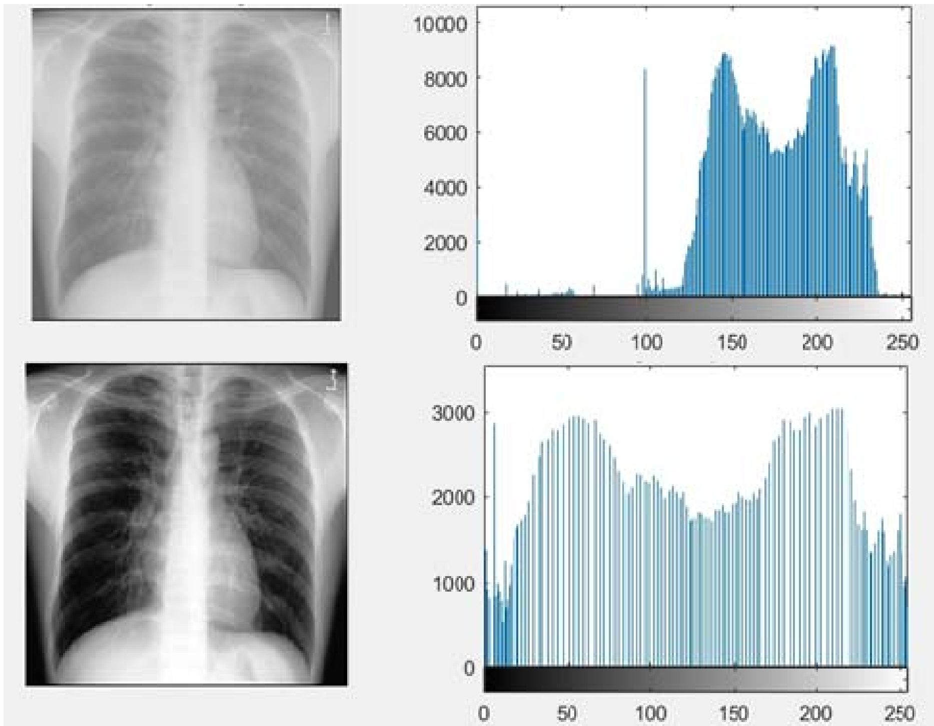

Figure 4. Results of the proposed method with their corresponding histograms after utilizing different thresholds.

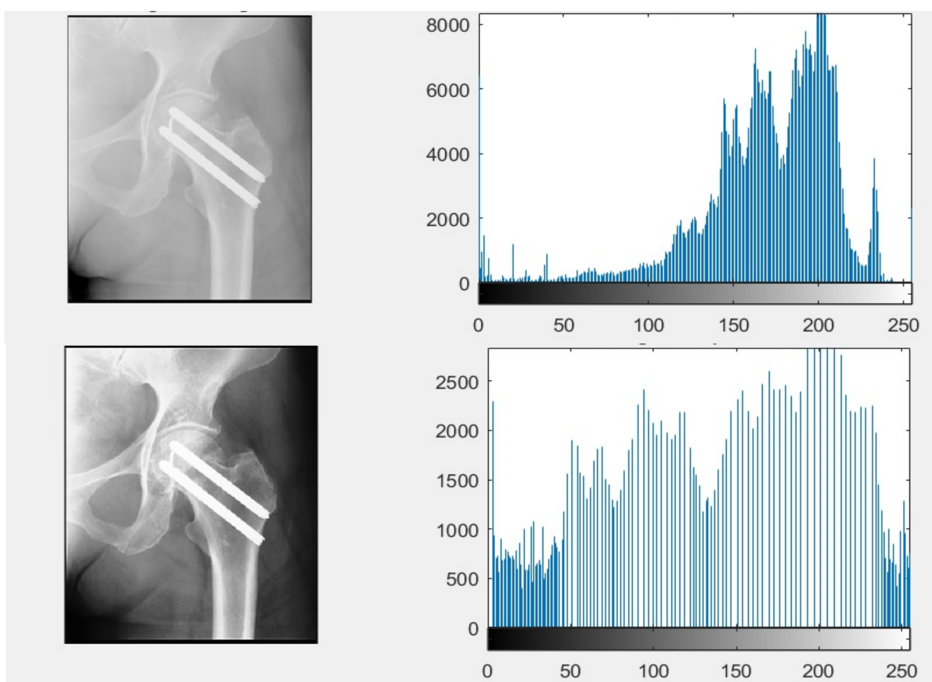

Figure 5. Results of the proposed method with their corresponding histograms after utilizing different thresholds.

REFERENCES

[1] T. A. Monica, “Medical image enhancement.” PhD Diss. University of Bucharest, 2005.

[2] H. R.Y. Huang, L. R. Dung, C. F. Chu, Y. Y. Wu, "Noise Removal and Contrast Enhancement for X-Ray Images." Journal of Biomedical Engineering and Medical Imaging, vol. 3, no. 1, pp. 56–67, 2016.

[3] K. K. Lavania, R. Kumar, “Image enhancement using filtering techniques.” International Journal on Computer Science and Engineering. vol. 4, no. 1 pp. 14–20, 2012.

[4] R. Y. Huang, L. R. Dung, C. F. Chu, Y. Y. Wu. “Noise Removal and Contrast Enhancement for X-Ray Images.” Journal of Biomedical Engineering and Medical Imaging. vol. 3, no. 1, pp. 56–67, 2016.

[5] http://www.cs.utah.edu/~ssingla/IP/P2/CLAHE.html.

[6] S. Sukhjinder, R. K. Bansal, S. Bansal. “Medical Image Enhancement using Histogram Processing Techniques followed by Median Filter.” International Journal of Image Processing and Applications, vol. 3, no. 1, pp. 1–9, 2012.

[7] Tan, Hong Sern. “Denoising of noise speckle in radar image.” BE Thesis, School of Information Technology and Electrical Engineering, the University of Queensland, 2001.

[8] B. Igor. “Homomorphic Filtering for Radiographic Image Contrast Enhancement and Artifacts Elimination.” Proceedings of the 3rd International Conference on Frontiers of Intelligent Computing: Theory and Applications (FICTA) 2014. Springer International Publishing, 2015.

[9] C. H. Bindu, B. S. Chandra. “Medical Images Enhancement by Homomorphic Filtering Equalization.” International Journal of Image Processing and Applications, vol. 3, no. 7, pp. 183–185, 2016.

[10] H. Wen, Q. Wu, L. Shuang. “Medical X-Ray Image Enhancement Based on Wavelet Domain Homomorphic Filtering and CLAHE.” International Conference on Robots & Intelligent System (ICRIS), pp. 249–254, 2016.

[11] P. S. Vikhe, V. R. Thool. “Contrast enhancement in mammograms using homomorphic filter technique.” International Conference on Signal and Information Processing (IConSIP), 2016.

[12] https://dsp.stackexchange.com/questions/15148/disadvantages-of-wavelet-transform, accessed, 05-09-2019.

[13] G. Hailan, and L Wenzhe. “A modified homomorphic filter for image enhancement.” 2nd International Conference on Computer Application and System Modeling, pp. 176–180, 2012.

[14] K. Pawanpreet, E. Aarti, A. Acet. “Denoising Digital Image using Wavelet Transform and Mean Filtering.” International Journal of Innovative Research in Science, Engineering and Technology, vol. 3, no. 4, pp. 330–336, 2014.

[15] S. S. Bedi, R Khandelwal. "Various image enhancement techniques-a critical review." International Journal of Advanced Research in Computer and Communication Engineering, vol. 2, no. 3, pp. 1605–1609, 2013.

[16] H. Yoon, H. Youngjoon and H. Hahn. “Image contrast enhancement based sub-histogram equalization technique without over-equalization noise.” World Academy of Science, Engineering and Technology, vol. 3, no. 2, pp. 189–195, 2009.

[17] H. Ibrahim, N. S. P. Kong, “Image sharpening using sub-regions histogram equalization.” IEEE Transactions on Consumer Electronics. vol. 55, no. 2, pp. 891–895, 2009.

[18] P. Shanmugavadivu, K. Balasubramanian, “Image Inversion and Bi Level Histogram Equalization for Contrast Enhancement.” International Journal of Computer Applications. vol. 1, pp. 69–73, 2010.