Contrast Enhancement Techniques to Improve the Quality of Medical Images

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ABSTRACT

Image contrast enhancement is important in medical applications. This is due to the fact that visual examination of medical images is essential in the diagnosis of many diseases. Different contrast enhancement techniques are used to improve the contrast of medical images such as histogram equalization, histogram modification techniques, morphological Filtering etc. This paper presents review of various contrast enhancement techniques and application of it in medical image enhancement.

Keyword: - *Medical images, contrast enhancement, quality etc..*

1. Introduction

Basically, the idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. A familiar example of enhancement is when we increase the contrast of an image because “it looks better”[1]. The term contrast, as observed in digital images, is the separation of dark and bright areas present in the image[13]. Image enhancement is dependent on the application context. An enhancement technique performing well in enhancing biomedical images may not be identically efficient in enhancing satellite images[9]. Medical images have an important role in diagnosing a disease and monitoring the effect of the selected treatments[8]. Emergency situations, environmental noises, patients’ special conditions in photography, lighting conditions and technical constraints of imaging devices are among the reasons why images may have low quality[8]. In such cases, image enhancement techniques can be useful, especially when reimaging is impossible. It is used to repair the damaged images, an efficient contrast enhancement technique can enhance small details of an image so that radiologists can properly monitor patient’s health condition, and they do not required to go for reimaging.

2. Histogram Equalization

Histogram Equalization (HE) is a very popular technique to perform contrast enhancement due to its simplicity and effectiveness [1]. In general, the HE distributes pixel values uniformly and the processing results in an enhanced image with linear cumulative histogram. It changes the brightness of an image and globally enhance the image. This technique is suitable for Poor lightened image. As known, the traditional HE method suffers from the unpleasant visual artifacts which makes HE often over-enhances the background of the image and causes level saturation effects in small but visually important areas, especially for chest x-ray images with motion artifacts by the cardiac beat. To overcome the visual artifacts of the traditional HE method and add more flexibility to it, many researches have already been done on histogram equalization in the past few years and many different improvement schemes have been proposed. Generally, we can classify these methods into two principle categories: (1) the improved global methods based on histogram equalization or histogram modification. and (2) the adaptive (or local) HE methods (named as AHE); Techniques based on global and local histogram equalization is given below.

3. Global HE Techniques

3.1 Brightness Preserving Bi-Histogram Equalization (BBHE):

In this technique image is decomposed into two sub images and equalizes both sub images independently. It preserves mean brightness of the image[22].

3.2 Dualistic Sub Image Histogram Equalization (DSIHE):

It decomposes an image into two equal area sub-images, one dark and one bright, based on its gray level cumulative probability density. Then the two sub images are taken in equalization process respectively. It enhance an image with its original luminance[24].

3.3 Recursive Mean-Separate Histogram Equalization(RMSHE):

This technique is an extension of BBHE technique, in this instead of decomposing the input image only once, it decompose the image recursively and equalize the image. It tends to preserve better brightness than HE, BBHE and DSIHE methods.

3.4 Recursive Separated and Weighted Histogram Equalization (RSWHE):

This technique is slightly different from above techniques, it first modifies the input histogram and then runs the equalization procedure[13]. It tends to preserve the image brightness and produces images with better contrast.

3.5 Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE):

This method also decomposes the input image in to two sub images and Histogram Equalization method is applied for both the sub images. In MMBEBHE we find the threshold level lt which decomposes the image I into two sub-images $I[0,lt]$ and $I[lt+1, L-1]$, so that the minimum brightness difference is achieved between the input image and the output image. The threshold level lt is the value that yields minimum AMBE. Once the input image is decomposed, both the sub images are enhanced separately using the Classical HE process [23].

In global contrast enhancement, pixels are modified by a transformation function based on the gray-level content of an entire image[1]. In this approach, the contrast stretching is limited in gray levels with high frequencies[25]. This causes significant contrast loss for gray levels having lower frequencies[25]. Although this global approach is suitable for overall enhancement, there are cases like a mammography images in which it is necessary to enhance details over small areas in an image. To overcome this problem, different Local Histogram Equalization (LHE) methods have been proposed.

4. Local HE Techniques

LHE techniques plays an important role in enhancing contrast of medical images. This technique is very useful for amplifying tiny anatomies, such as airways, vessels, lung nodules and pulmonary fissures in the lung CT images[11].

4.1 AHE

This technique divides the image into several non-overlapped sub-images and derives their histograms and modifies the histogram to enhance the contrast of the pixels within the sub-images. This way AHE enhance local contrast of an image.

4.2 CLAHE

Contrast-Limited Adaptive Histogram Equalization (CLAHE) is an adaptive contrast enhancement method. It is based on adaptive histogram equalization. Adaptive Histogram Equalization is an extension to conventional Histogram Equalization technique. It locally enhance the image, so this technique is suitable when object in image is not easily perceivable. The CLAHE algorithm partitions the images into contextual regions and applies the histogram equalization to each one[10]. S.Muniyappan et al. 2013 proposed a contrast enhancement technique for mammography images based on CLAHE technique.

However, LHE requires high computational cost and sometimes causes over-enhancement in some portion of the image. Another problem of these methods is that it also enhances the noises in the input image along with the image features. Nonetheless, most of the time, these methods produce an undesirable checkerboard effects on enhanced images.

5. Morphological Transform

In morphology, the objects in an image are considered as set of points and operations are defined between two sets: the object and the structuring element (SE).

5.1 Single scale morphological filtering:

Single scale morphological filtering performs image enhancement using the morphological top hat transform corresponding to the size/scale of the used structuring element. Local contrast enhancement can be achieved by adding an original image to the difference between top-hat and bottom hat transformed image[9]. This is done as follows:

$$f_0 = f + f_{TH} - f_{BH} \quad [9]$$

where f is the original image, f0 represents the final enhanced image, fTH represents the extracted white image regions using top hat transform, fBH represents the extracted black image regions using bottom hat transform.

5.2 Multi scale morphology:

A morphological operation with a scalable structuring element can extract features based not only on shape but also on size. Also features of identical shape but of different size are now treated separately. Such a scheme of morphological operations where a structuring element of varying scale is used is termed as multiscale morphology. Multiscale morphology is used to enhance the contrast of the image at various scales or sizes of the structuring element[9]. Use of multiscale morphological transform to enhance the contrast of medical images, by exponentially increase size of disc shaped mask, it gives enhanced image per mask and after that CIR(Contrast Improvement Ratio) measure is used to select final contrast enhanced image[8].

6. Neural networks in image enhancement

Artificial Neural Network (ANN) is closely related to image processing task[3]. Nowadays researches in the field of image processing are actively used neural networks[3]. One advantage of using ANN is the ability of ANN to adapt, which appear in form of internal characteristics changing of ANN to perform particular task[3]. Contrast enhancement based on artificial neural networks has many important advantages in solving problems that are too complex for conventional technologies[3]. A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships[3]. Use of Neural networks for the contrast enhancement of images that includes colored images like stained media for TB bacilli has been proved an important tool for diagnostic purpose as the visibility is increased. The role of feed-forward ANNs and Self Organizing Maps has been extended to encompass also low-level image processing tasks such as noise suppression and image enhancement[14]. The majority of the ANNs were applied directly to pixel data. Tsai et al. has train a Hopfield network for enhancement of endocardiac borders. Waxman et al. [17] consider the application of a centre-surround shunting feed-forward ANN (proposed by Grossberg) for contrast enhancement and colour night vision. In several other applications, regression or classification (mapping) networks were trained to perform image restoration or enhancement directly from pixel data. Neural networks perform in two different modes, learning (or training) and testing. And there are algorithms in ANN, which trains net for different applications. We can see presence of these algorithms in medical science too[14]. As these algorithms train net for diagnosing different diseases of patients.

7. CONCLUSION

A survey of various contrast enhancement techniques is presented along with their comparison. Many image contrast enhancement techniques like Histogram Equalization (HE), Morphological Transform etc have been reviewed and compared. Local enhancement is not handled by HE, BBHE, DSIHE, MMBEBHE, have been properly enhanced by AHE and CLAHE techniques. We can train the neural network for enhancement of medical images it overcomes the shortcoming of under enhancement and enhances the image to correct extent.

8. REFERENCES

[1]. Gonzalez, Rafael C. Digital image processing. Pearson Education India, 2009.

[2]. Hagan, Martin T., Howard B. Demuth, and Mark H. Beale. Neural network design. Boston: Pws Pub., 1996.

[3]. A.S.W. Wahab,M.Y. Mashor, Zaleha Salleh, S. A. Abdul Shukor, N. Abdul Rahim,F.Muhamad Idris, H. Hasan, S.S. Md Noor. A Neural Network Approach for Contrast Enhancement Image. International Conference on Electronic Design; 1-3 Dec.,2008; Penang, Malaysia.

[4]. Suzuki K, Abe H, MacMahon H, Doi K. Image-processing technique for suppressing ribs in chest radiographs by means of massive training artificial neural network (MTANN). IEEE Transactions on Medical Imaging 2006;25(4).

[5]. Jiang, Jianmin, P. Trundle, and Jinchang Ren. "Medical image analysis with artificial neural networks." Computerized Medical Imaging and Graphics 34.8 (2010): 617-631.

[6]. Ma, Yide, et al. "A novel algorithm of image enhancement based on pulse coupled neural network time matrix and rough set." Fuzzy Systems and Knowledge Discovery, 2007. FSKD 2007. Fourth International Conference on. Vol. 3. IEEE, 2007.

[7]. Sharma, Cheenu, and Rupinder Kaur. "A HYBRID APPROACH USING GENETIC ALGORITHM AND NEURAL NETWORK FOR IMAGE CONTRAST ENHANCEMENT."

[8]. Hassanpour, Hamid, Najmeh Samadiani, and SM Mahdi Salehi. "Using morphological transforms to enhance the contrast of medical images." The Egyptian Journal of Radiology and Nuclear Medicine 46.2 (2015): 481-489.

[9]. Kaur, Sandeep. "Contrast Enhancement Techniques for Images-A Visual Analysis." International Journal of Computer Applications 64.17 (2013).

[10]. Muniyappan, S., A. Allirani, and S. Saraswathi. "A novel approach for image enhancement by using contrast limited adaptive histogram equalization method." 2013 Fourth International Conference on Computing, Communications and Networking Technologies (ICCCNT). IEEE, 2013.

[11]. Zhang, Guodong, et al. "A contrast enhancement algorithm for low-dose CT images based on local histogram equalization." Bioinformatics and Biomedical Engineering, 2008. ICBBE 2008. The 2nd International Conference on. IEEE, 2008.

[12]. Chen, Soong-Der, and Abd Rahman Ramli. "Contrast enhancement using recursive mean-separate histogram equalization for scalable brightness preservation." Consumer Electronics, IEEE Transactions on 49.4 (2003): 1301-1309.

[13]. Gupta, Shefali, and Yadwinder Kaur. "Review of Different Local and Global Contrast Enhancement Techniques for a Digital Image." International Journal of Computer Applications 100.18 (2014): 18-23.

[14]. Egmont-Petersen, Michael, Dick de Ridder, and Heinz Handels. "Image processing with neural networks—a review." Pattern recognition 35.10 (2002): 2279-2301.

[15]. Hari, Parli B. "Diagnosis Techniques in Medical Technology using Soft Computing."

[16]. C.-T. Tsai, Y.-N. Sun, P.-C. Chung et al., Endocardial boundary detection using a neural network, Pattern Recognition 26 (7) (1993) 1057–1068.

[17]. A.M. Waxman, M.C. Seibert, A. Gove et al., Neural processing of targets in visible multispectral IR and SAR imagery, Neural Networks 8 (7–8) (1995) 1029–1051.

[18]. T Yafei, WAN Qingtao, WU Fengjun. "Local Histogram Equalization Based on the Minimum Brightness Error", 4th International Conference on Image and Graphics (ICIG 2007), pp. 58–61, 2007.

[19]. Soong-Der Chen, Abd. Rahman Ramli. "Minimum Mean Brightness Error Bi-Histogram Equalization in Contrast Enhancement", IEEE Transactions on Consumer Electronics, Vol. 49 pp. 1310–1319, 2003.

[20]. J-Y. Kim, L-S. Kim, and S-H. Hwang, "An Advanced Contrast Enhancement Using Partially Overlapped Sub-block Histogram Equalization", IEEE Trans. on Circuits and Systems for Video Technology, Vol. 11, Issue 4, pp. 475–484, 2001.

[21]. Q Wang, RK Ward. " Fast Image Video Contrast Enhancement Based on Weighted Thresholded Histogram Equalization", IEEE Transactions on Consumer Electronics, Vol. 53(2), pp. 757–764, 2007.

[22]. Kotkar, Vijay A., and Sanjay S. Gharde. "Review of various image contrast enhancement techniques." International Journal of Innovative Research in Science, Engineering and Technology 2.7 (2013): 2786-2793.

[23]. Krishna, Dr A. Sri, G. Srinivasa Rao, and M. Sravya. "Contrast enhancement techniques using Histohram Equalization methods on color images with poor lightning." International Journal of Computer Science, Engineering and Applications (IJCSEA) Vol 3 (2013).

[24]. Kaur, Manpreet, Jasdeep Kaur, and Jappreet Kaur. "Survey of contrast enhancement techniques based on histogram equalization." IJACSA) International Journal of Advanced Computer Science and Applications 2.7 (2011).

[25]. Hashemi, Sara, et al. "An image contrast enhancement method based on genetic algorithm." Pattern Recognition Letters 31.13 (2010): 1816-1824.