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Medical image contrast enhancement techniques

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ABSTRACT

Image enhancement on an image is a process to make it ready for further uses in certain applications. It enhances the visual property and the intelligibility of image thereby making the resultant image more beneficial for processing. This literature review covers a wide range of contrast enhancement techniques based on contrast manipulation for medical images such as CT, X-RAY, MRI and MAMOGRAM images. Also this review gives more detailed information about different novel medical image contrast enhancement techniques, efficient contrast enhancement algorithm approaches and so quality metrics which are useful and applicable in medical image analysis and clinical diagnostic synthesis.

Keywords: mammogram, contrast enhancement technique, computer tomography

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INTRODUCTION

Generally medical images were poor quality in contrast and contains a lot of uncertainties. Medical image enhancement improves visual appearance and enables identification of the desired region of the image. Medical imaging plays a leading role in modern diagnosis and contrast enhancement of medical images are useful in helping the radiologist or surgeons to detect pathologic or abnormal regions. Medical image enhancement processing is superior for present plain human tissues and organs and is moreover excellent for aided diagnosis. In recent years different contrast enhancement algorithms are proposed by many researchers. There are many defects in the traditional image contrast enhancement techniques which usually processes the whole image and will hide both partial and specific information partly, and these methods will be inferred by the noise easily. Therefore, it cannot meet the requirements of the medical image processing.

There are four important diagnostic tool in the medical field :a) X-RAY: mostly used imaging modality to check bone fractures and related problems in human internal body structure .b) CT: computer tomography is the imaging method of the choice in the assessment of multiple trauma patients. c) MAMO GRAM: it is an essential medical imaging of early detection and diagnosis of breast cancer diagnosis. d).MRI: Magnetic Resonance Imaging method uses Magnetic field and radio waves to create detailed pictures of the organs and soft tissues and bones within our body structure and widely used in hospitals for medical diagnosis

In recent years automated medical diagnosis systems are developed to detect abnormalities in human. It involves contrast enhancement to highlight the region of interest (ROI). Image segmentation to extract abnormalities region and features extraction to represent abnormalities. Contrast enhancement refers to highlight the low frequency component or high frequency component of the medical images based on the application. Image smoothening is performed to highlight the low frequency region by blurring and by removing the fine details. Averaging, Weighted

averaging and low pass filtering are used for the above purpose. On the other hand Robert Privitte, Sobell Laplacian filters are used to highlight high frequency details. In addition to these filters various point operators namely Image negative, log transform, power law transformation, histogram equalization are also listed in the literature. Owing to the inherent complexities in real time medical imaging contrast enhancement techniques developed for a set of medical images do not work well for the other set of images.

In this paper a detailed literature review is conducted on the various contrast enhancement techniques used for medical images.

II. LITERATURE REVIEW

Shyam Lal and Mahesh Chandra[2014), proposed an efficient algorithm for contrast enhancement of natural I mages. This new contrast enhancement algorithm used modified sigmoid function to progression the poor quality of an image and the output of the first stage is further developed by measure and enhances the local contrast of the images so that the fine details of mammograms can be enhanced and the noise can be concealed. The global information provided by the histogram of the mammogram and the fuzzy entropy of local window is computed to evaluate the local information. Then, both the global and local information used to describe and enhance the contrast. Finally, the enhanced mammogram transformed back to spatial coordinates by defuzzification. The experimental results proved that the proposed method can successfully enhance the contours and fine details of the mammographic features which will; useful for breast cancer diagnosis. [1]

B.Ganesan et al (2013) developed a hybrid contrast enhancement technique preferably for medical image .The work deals with CT images using single seed based region growing adaptive enhancement techniques. when compared to the existing techniques such as adaptive enhancement and linear stretching this technique gives better performance . In future by selecting multiple seed point based multiple objective clustering technique the work will be extended and may further extended using different hybrid Image Enhancement techniques. Additionally, the Medical Images may be differentiated for normal and abnormal portions of different organs of human body using Enhanced Image Segmentation technique[2]

V. Magudeeswaran and C. G. Ravichandran (2013)planned a Fuzzy logic-based histogram equalization (FHE) for image contrast enhancement. To overcome the unwanted over enhancement and noise amplifying, the fuzzy logic-based histogram equalization technique is proposed for both gray scale and color images. The FHE consists of two stages. Initially, fuzzy histogram is calculated based on fuzzy set theory to grip the imprecision of gray level values in a superior way compared to classical crisp histograms. In the subsequent stage, the fuzzy histogram is alienated into two sub histograms based on the median value of the original image and then equalizes them alone to preserve image brightness. In addition, fuzzy histogram equalized images uses full dynamic range of the pixel values for maximum contrast. From the qualitative and quantitative measures like reminiscent of average information contents (AIC) and natural image quality evaluator (NIQE) index for various images , it is fascinating to see that this proposed method provides most advantageous results by giving better contrast enhancement and preserving the local information of the original image The l outcomes of this method for different images show that the proposed method can effectively and significantly eliminate washed-out appearance appeared in low light environment images, undesirable checkerboard effects which are observed in the low resolution images, and significant change in image brightness and adverse artifacts induced by several existing methods. This method is simple and suitable for consumer electronic products.[3]

Ritika et al (2013), provided an overview of an analysis of the mathematical morphological approach with comparison to various other state-of-art techniques Histogram Equalization (HE) and Contrast Limited Adaptive Histogram Equalization (CLAHE) for low contrast in images along with their visual comparison. Morphological Contrast enhancement is performed at a single scale or at multiple scales of the structuring element which can be of various shapes and sizes using the white and black top-hat transformation. The various contrast enhancement techniques like Histogram Equalization, Contrast-Limited Adaptive Histogram Equalization, Single Scale Morphological Filtering and Multistage Morphological Filtering are implemented on a set of medical images like heart, Brain, Kidney images etc and the using the experimental visual results it was proven that the multistage morphological approach provides good results in comparison to the results obtained with other state-of-art techniques. Multistate morphological approach has been successfully used in local contrast enchantments. It enhances the local contrast of the images satisfactorily.[5]

Zohair Al-Ameen et al (2013), provided an overview of adjusting the contrast of degraded CT images before beginning the restoration process. A comparison between seven famous techniques was conducted likewise to choose the best method among the different popular contrast enhancement methods. Then, experiments were conducted to show that adjusting the contrast before restoring CT images would lead to better restoration results. From the obtained results the image that was restored without contrast adjustment shows less visual details than the one that is contrast adjusted, and it's a similar situation in the case of de-noising. Moreover, this revise provides good evidence about the necessity of employing a contrast adjustment technique before restoring degraded CT images. The conduced experiments show that various features from the affected CT images could be revealed and preserved when adjusting their contrast before restoration process starts using a reliable contrast enhancement method.[6]

R.Senthilkumar et al (2014), in his paper provides an analysis of only three types of image enhancement techniques such as HE, AHE and CLAHE histogram modification methods for enhancement of Chest X-ray images and are implemented in MATLAB environment. The performance of these techniques is then compared using various parameters such as Peak signal to noise ratio (PSNR), Mean squared error (MSE), Signal to noise ratio (SNR), Absolute mean brightness error (AMBE) and Entropy. From the experimental results; it was proven that CLAHE was competent when compared to other two methods. CLAHE was at first developed for medical imaging and has confirmed to be successful for enhancement of low-contrast images such as x-ray images and portal films.[7]

Sanjeev Kumar et al (2014), in his paper provided an overview on the analysis of different contrast enhancement techniques in image processing for example Linear Stretch. Histogram Equalization, Convolution mask enhancement, Region based enhancement, Adaptive enhancement and offered a latest technique for contrast enhancement and offered a latest technique for contrast enhancement of X-Ray images. In the above mentioned techniques, the enhancement of the background detected image is done using Weber's law (modified Weber's law for compressed domain). These techniques are implemented in gray scale and after that extended to color images by separately enhancing the color components. The analysis of proposed technique done for various background images, majority of them in poor illumination condition and the proposed technique compared against the existing major contrast enhancement techniques and has been performed in MATLAB. The technique used in the Adaptive Region Growing approach for contrast enhancement is point dependent thus selection of point is extremely significant. A point selected in darker regions will offer superior results that the point selected in brighter region. From the experimental results it was proven that the Adaptive Region Growing approach is coming up with better results. The approach may be implemented for other type of medical images various de-noising technique may also be incorporated in the algorithm to improve the high noise images. Performance evaluation of this algorithm was done on several X-Ray images on case-by-case basis of quality metrics like SNR, contrast-to-noise ratio and Tenangrad measurement.[8]

Udaykumbhar et al (2013), in this paper gives the simple rule to enhance the Medical images using MATLAB. The main objective of this revise is to get better features and increase better characteristics of medical images for a right diagnosis. In the Proposed method image, enhancement processing consists of Median filter for cutback noise, Un Sharp Mask filter (USM) for edges sharpening, Contrast Limited Adaptive Histogram Equalization (CLAHE) for contrast enhancement, and finally Average (mean) filter for smooth figures. Medical images were usually poor quality especially in contrast. For solving his problem, in this paper a Contrast Limited Adaptive Histogram Equalization (CLAHE) which is one of the techniques in a computer image processing domain is proposed. Contrast limited adaptive histogram is a technique utilized for improving he local contrast of images. Problems associated with HE and AHE can be limited by reducing contrast enhancement particularly in homogeneous areas. The algorithm (Contrast Limited Adaptive Histogram Equalization (CLAHE) limits the slop associated with the gray level assignment scheme to prevent saturation. The proposed methods have applied on different CT, X-ray, MRI and Angiogram medical images.[9]

Heng-da Cheng et al (2002), proposed an adaptive fuzzy logic contrast enhancement method to enhance mammographic features which is significant and crucial to breast cancer diagnosis. In this approach, initially the mammograms are normalized to reduce the effects of diverse illuminations. Then, the normalized images are fuzzified based on the maximum fuzzy entropy theory. Both the inclusive and neighboring information of the mammogram are utilized are utilized to measure and enhance the local contrast of the images so that the fine details of mammograms can be enhanced and the noise can be concealed. The global information provided by the histogram of the mammogram and the fuzzy entropy of local window is computed to evaluate the local information.

Then, both the global and local information used to describe and enhance to contrast. Finally, the enhanced mammogram transformed back to spatial coordinates by defuzzification. The experimental results proved that the proposed method can successfully enhance the contours an fine details of the mammographic features which will be useful for breast cancer diagnosis.[10]

T.A.Sangetha et al(2012), in this paper, designed an efficient technique to enhance the mammogram image using various transforms. This whole drawback is overcome by the Non sub sampled Contour let transform. The experiments were conducted using two UCI machine learning dataset in turn to vary the effectiveness of the proposed technique. Observe that all the transform in which the non sub sampled contour let transform is the best and more efficient method to enhance the images. It suppresses noises while enhancing weak edges in the textures and boosting the contrast between the lesion area and the background. The performance evaluation of this method was prepared based on the PSNR value and MSE. By the comparison of PSNR and MSE Values for Various Transform proved that the non sub sampled transform is reliable and accurate one for image enhancement. Comparing with other methods it is useful in capturing relevant clinical information since its PSNR value is high and has very low MSE value.[11]

Ching-Chum Huang et al (2014), in his paper proposed a method based on tissue attenuation to enhance the bright regions of an X-ray images which are of interest since most important matters compactly locating ;in those regions. In this method assumed that the X-ray intensity is composed of tissues and other important details. The important details particularly in the bright regions of the X-ray images could adaptively enhanced by locally attenuating the ratios of tissues over the image. A two-step procedure was proposed to adjust the ratios. First, the tissue element was alienated from a given image based on local contrast maximization. Second, an attenuation correction was performed to control the ratio of detachable tissues in order to appropriately enhance contrast. Experimental results also reveal the efficiency of this method.[12]

Xuanqin Mou et al (2008), in his paper, presented a Nonlinear multi-scale contrast enhancement algorithm for nonlinear chest radiograph images contained by the multi-scale decomposition architecture in spatial domain. However, conventional multi-scale methods suffered from visible artifacts to some extent. In this approach particularly by using local contrast information, one type of nonlinear enhancement function is calculated. This model primarily avoids visible artifacts by contributing the local adaptive enhancement ability, while keeping the same detail enhancement ability. In the period in-between, comparing to conventional methods no excessive noise is amplified. The effectiveness of the proposed algorithm was evaluate using a demonstrated chest image and proved that this technique has superior performance than standard techniques.[13]

Agarwal. T.K. et al (2014), proposed a new method named “Modified Histogram Based Contrast Enhancement using Homomorphic Filtering” (MH-FIL) for medical images. Histogram based techniques are used to enhance low contrast of all type of medical images such as for Mias-mammogram images. And these methods are used to find exact locations of cancerous regions and for small-amount CT images, and also these methods are used to intensify tiny anatomies like vessels, lungs nodules, airways and pulmonary fissures from chest CT images. This method uses two step procedures, in first step global contrast of image is enhanced using histogram modification followed by histogram equalization and then in the second step homomorphic filtering is used for image sharpening. And this filtering is followed by image normalization. The efficiency of this method is evaluated by selecting two widely used metrics Absolute Mean Brightness Error (AMBE) and Entropy. Based on consequences of these two metrics this algorithm is proved as a flexible and efficient for medical image enhancement and can be closed a pre-processing step for medical image understanding and analysis.[14]

Shelda Mohan et al, in his paper presented new optimized Histogram based contrast limited enhancement technique based on entropy and edge information of the image for mammogram image enhancement which is considered as an optimization problem and is essential for the detection of mass and micro calcification in mammogram images. Based on local contrast modification (LCM), Contrast Limited Adaptive Histogram Equalization (CLAHE) enhancement function used in the technique. The sobel operator; is used for finding micro calcification in mammograms and to test its enhancement potential. But in mammogram images local details are more important that global details for the recognizing cancerous cells. Accordingly in the proposed method we have used a local contrast enhancement (LCM) to show up the fine details hidden in the mammogram image and an enhancement parameter to manage the level of enhancement along with standard CLAHE and an Optimization technique to tune the enhancement parameter. So incorporating LCM with CLAHE and Optimization technique produces an optimal

contrast enhancement with all local information of mammogram image which may not be obtained using Standard CLAHE. Results are compared with other enhancement techniques such as Histogram Equalization, Unsharp Masking and CLAHE. The proposed method produce better results with proper tuning of parameter. But in case of Standard Histogram Equalization, Unsharp masking and Normal CLAHE it produces only one enhanced image for a particular input image.[15]

M.Sundaram, et al (2011), in this paper introduced the Histogram Modified Local Contrast Enhancement (HM-LCE) to adjust the level of contrast enhancement, which consecutively gives the resultants image a strong contrast and also brings the local details present in the original image for more significant interpretation. The standard histogram equalization (HE) usually results in excessive contrast enhancement because of lack of control on the level of enhancement. The two processing stages involved in this method are a histogram modifications as an optimization technique and a local contrast enhancement technique. This technique is tested for Mias mammogram images and using three parameters like Enhancement Measure (EME), Absolute Mean Brightness Error (AMBE) and Discrete Entropy (H), the performance was evaluated for all 22 numbers of Mias mammogram images with micro calcification. The enhancement potential of this technique was tested by sobel and otsu methods for the detection of micro calcification in the mammogram image. From the subjective and quantitative measures it is attractive that this proposed techniques provides optimum results by giving better contrast enhancement and preserving the local information of the original mammogram images in the Mias data base and the method has increased the detestability of micro calcifications present in the given mammogram image.[16]

Karen panetta et al (2011), in this paper introduced a new unsharp masking (UM) scheme, called nonlinear UM (ULUM), for mammogram enhancement. The NLUM offers users the flexibility 1) to implant different types of filters in to the non linear filtering operator; 2) to select different linear or non linear operation for the fusion processes that combines the enhanced filtered portion of the mammogram with the original mammogram; and 3) to permit the NLUM parameter choice to be performed physically or via a quantitative enhancement evaluation to acquire the optimal enhancement parameters . They also launched the second –derivative like measure of enhancement, anew enhancement measure approach. The human visual system based image decompositions is used for analysis and visualization of mammogram enhancement. In evaluating the visual quality of image enhancement, this new approach performs better com[pare to other approaches. The comparison and evaluation of enhancement performance shown that the NLUM can progress the disease diagnosis by enhancing the find details in mammograms with no prior knowledge of the image contents.[17]

Sonia goyal et al (2011), in his paper presented a hybrid methodology for image enhancement of low contrast MRI images. In this work a seed based region growing approach; is used for enhancement of MRI images. The approach has been fused with CLAHE and producing better results. On comparing the proposed methodology with the existing popular approaches of adaptive enhancement and region growing enhancement techniques on both qualitative and quantitative basis, it has been concluded that the proposed technique in giving much better results than the existing ones. For validating the visual results, Illusion MRI image has been used.[18]

Dr.S.S.Bedi et al (2013), in his paper proposed technique which uses multi-image Contrast enhancement for PCA fusion of medical images such as brain MRI images based on Principal Component Analysis and to improve the visibility of medical images by applying contrast enhancement existing techniques like Histogram Equalization (HE), adaptive Histogram Equalization (AHE) etc., The PCA fusion procedure adopted at this point get better resolution of the images. In this paper the combination of PCA for the fusion of brain MRI images and existing contrast enhancement techniques for enhancement of fused images has been projected. A qualitative comparison and numerical analysis is done on the basis of quality metrics like PSNR. etc. From the simulation results it is noticeable that the resultant fused image and contrast enhanced image consists of information liberated from unnecessary artifacts or distortion which aids in clinical diagnosis. Finally it is proved that the PCA and Linear Stretch is more apt for human brain Magnetic Resonance image fusion, because this provides high PSNR value means resulting with a reduction of noise that PCA and HE and PCA and AHE.[19]

Arpita Das et al,proposed algorithm which launches a new indistinct approach to develop a discriminating but robust, flexible and smart contrast enhancement technique for mammograms. Wavelet based filtering study can generate Low Frequency (LF) and High Frequency (HF) sub bands of the original input images. The very little small size micro calcifications become visible under multi resolution techniques. LF sub band is then fuzzified by conventional fuzzy c-means clustering (FCM) algorithm with necessary number of clusters. HF components,

representing the fine protrusions and other fine details are also fuzzified by FCM with justified number of clusters. Vague set approach captures the hesitancies and suspicions of truly affected masses/other breast abnormalities with normal glandular tissues. After highlighting the masses/micro calcifications accurately, both LF and HF sub bands are transformed back to the original resolution by inverse wavelet transform. The results shown that the proposed method can successfully enhance the selected regions on mammograms and provide better contrast images for visual interpretation.[20]

Shibin Wu et al (2013), proposed a new algorithm for feature and contrast enhancement of mammographic images. Based on multi-scale transform and mathematical morphology. The Laplacian Gaussian pyramid operator transforms the mammography into different scale sub band images which are equalized by contrast limited adaptive histogram equalization (CLAHE) and low-pass sub images are processed by mathematical morphology. Finally, the enhanced image feature and contrast is reconstructed from the Laplacian Gaussian pyramid coefficients and then processed by global nonlinear operator. The performance evaluation of the proposed algorithm is measured by contrast evaluation criterion for image, signal-noise-ratio (SNR), and contrast improvement index (CII) and compared with the existing popular approaches of histogram equalization and adaptive histogram equalization, nonlinear multi scale processing based on Laplace pyramid, and the method based on wavelet transform and morphology. This algorithm is effective for feature and contrast enhancement of mammogram which enhance the local detail information and edges, and also restrict the modified noise are more suitable for clinic application.[21]
Chaira and Tamalika (2013), suggested a novel method for contrast enhancement of medical images using Type II fuzzy set theory this approach used a new fuzzy membership function which is formed using an aggregation operator hamacher T co norm and the upper and lower membership function of Type II fuzzy set. The average of the image is used to compute the parameter in the Hamacher T co norm. The image with the new membership function is an enhanced image. Type II fuzzy set considers fuzziness in fuzzy membership function; it may be a good tool for medical image analysis because of medical images contains a lot of uncertainties. Compared with non-fuzzy, intuitionistic fuzzy and the existing Type II fuzzy methods this new method is effective and performs better that existing methods.[22]

Ashamdeep Singh and Navdeep Kanwal (2013),in this paper suggests a new hybrid approach for enhancement of the digital images which is based on region growing segmentation and works adaptively for enhancement of the image. Further, the technique is seed dependent, a seed chosen in darker regions will give better results than the seed chosen in brighter region… The image is enhanced for the foreground part and clubbed with its original gradient and performs the morphological operations as texture analysis in the end. Verification of the results has been done on the basis of quality metrics: Tenangrad Measurement, Entropy & Mean square error. The proposed algorithm is enhancing the image more precisely in comparison to other algorithms. The evaluation derives that Proposed Enhancement technique produces better quality values for enhancement image. The approach may be adopted for medical images.[23]

Faisel G.Mohammed et al (2013), proposed a technique, used to enhance medical images in the spatial domain using spatial filter (like, Sobel, Laplacian and Smoothing) Smoothing filters are used for blurring and for noise reduction. In additional, some logical and arithmetic operators have been used (like, and, sum, subtract). A hybrid strategy for image enhancement by combining spatial enhancement with power-law transforms function has been implemented. For the effectiveness, this technique evaluated using tested low medical x-ray images in terms of statistical measures MAE and enhancement in spatial domain is performed by using object error criterion MAE (mean absolute error).[24]

Sameer Singh and Keir Bovi(25) (2005), proposed a novel set of metrics that evaluate the quality of the image enhancement of mammographic images in a computer aided detection frame work intended at repeatedly verdicting masses via machine knowledge based techniques. Our methodology consists of a new method for the mixture of metrics projected into a distinct quantitative measure. In this context a total of six image enhancement techniques are used namely (histogram equalization HISTOEQ, adaptive contrast enhancement(ACE, density weighted contrast enhancement(DWCE), adaptive contrast enhancement based on local entropy(ACELE) and adaptive contrast enhancement based on fractal dimension(ACEFD). From the simulation results i.e. is observed that technique such as ACE and ACELE present poorly. While , techniques such as DWCE and FUZZY visually shows improved results. The HISTOEQ gives best contrast enhancement crossways all synthetic images.[25]

Srikant Khanna and V. Chandrasekaran,proposed a novel techniques based on fractional derivatives for preprocessing of digital images which deals mainly with the texture enhancement and the other issues to a small amount. In this context, multidirectional Grunwald-Letnikov derivative based fractional derivative mass is proposed for image contrast enhancement in several directions in one pass. According to the desired blur improvement the standard prediction network studies training set of images and find outs the fractional order based on the handouts of the image. Also achieves the controlled blur reduction. For the performance evaluation this proposed novel filter experimented on a large number of images and as per the comparative blur metrics and multidirectional mask effectively improves the image contrast in the numerous directions in one pass and is distinctive. [26]

S.S.Chong et al (2013) , proposed a modified version of hyperbolic algorithm contrast enhancement technique based suitable for magnetic resonance imaging(MRI) which has higher sensitivity than mammography in breast cancer detection. In this technique in adequate contrast enhancement of breast MR image obtained by controlled fashion of the gray level stretching on each breast structure. A numerical and visual comparative analysis for numerous existing contrast enhancement techniques. From the experimental result it is proven that this technique get better the contrast of granular tissues and fatty tissues in addition to prevents over enhancement of the image by preserving the brightness of the overall image.[27]

CONCLUSION

In this literature survey, reviewed on different image contrast enhancement techniques gives the best solution to solve the problem produced by the poor contrast medical images. This review is very useful for medical experts and researchers to analyze medical image diagnostic problem. Even each of these techniques have its own merits and proven as best suitable for particular type of medical images such as CT,X-RAY,MRI and MAMOGRAM images that may fail for another type of images . However no single contrast enhancement methodology is the stand alone for all above mentioned medical images. The work may be further extended for a comparative analysis of medical image contrast enhancement techniques.

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