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Comparison Review of Medical Image Enhancement in Spatial and Wavelet Transformation Domain

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Abstract— Today the medical imaging has become an essential part of modern medicine, which runs through the whole clinical work. The result of medical imaging can offer the effective basis for choosing the proper pharmacy [2]. The medical imaging is that process which is used to create visual representation of the interior of the body for the clinical analysis and medical intervention. Medical image is produced by different techniques like Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography (CT) and Ultrasound. During the acquisition of a newly medical image, it contains the lot of noise. The most common distortions in medical images is their poor contrast quality, out of focus, blurness, improper brightness and noise. These problems makes difficult to diagnosist to diagnose the internal organism problems of human body. The image enhancement is the solution to solve these problems so that the internal organism problems of the human body can be easily detect by the diagnosist. I have reviewed the different paper regarding medical image enhancement and analyzed that there are different kind of enhancement techniques like spatial transformation, wavelet transformations, image fusion, contrast stretching etc. which are to be used to enhance the medical image.

Keywords—Image enhancement, SWT, PSNR, MSE, RMSE

I. INTRODUCTION

Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing `better' input for other automated image processing techniques. The principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. Moreover, observer-specific factors, such as the human visual system and the observer's experience, will introduce a great deal of subjectivity into the choice of image enhancement methods.

Medical Image Enhancement:- Medical image is produced by different techniques like Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography (CT) and Ultrasound. During the acquisition of a newly medical image, it contains the lot of noise. The image enhancement is the solution to solve these problems so that the internal organism problems of the human body can be easily examine. Image enhancement is a technique which is used to obtain the detail that is hidden in an image or to improve the quality of the medical image, reduce the noise, improve contrast or all other problem that are acting as a barrier during the examination of the medical image to detect the exact internal organism problem of human body.[2]. The enhancement methods can broadly be divided in to the following two categories:

1. Spatial Domain Methods [1]
2. Frequency Domain Methods

A. Spatial Domain Technique:-

In spatial domain techniques we directly deal with the image pixels. The desired enhancement is achieved by manipulating the pixel values. The techniques comes under spatial domain technique like logarithmic, power law transforms, histogram equalization are based on the direct manipulation of the pixels in the image. The spatial techniques are useful for altering grey level of each pixel and overall contrast of the entire image. With this the whole image is enhanced in a uniform manner, which produces the undesirable results.

The operations of spatial domain method can be formulated as

$$g(x,y)=T[f(x,y)]$$

Where g is an output image
f is an input image &
T is an operation on f defined over some neighbourhood of(x,y)

$$g(x,y)=f(x,y)*h(x,y)$$

These approaches can be classified into three categories:-

1. Intensity transformation function
2. Histogram Processing
3. Spatial filtering operations

B. Frequency Domain

The images in frequency domain are developed by using frequency filter. Transformation or frequency domain techniques are not based on image itself. They are based on the manipulation of orthogonal transform of the image. Transformation domain techniques are suitable to process the image according to its frequency content. Computation of 2-D discrete unitary transform of image is the principle behind the frequency domain methods. Here the transform coefficient are manipulated by an operator M, and after that performs the inverse transformation. In the orthogonal transform of image has two components magnitude and phase. The magnitude consists of the frequency content of the image. The phase is used to restore the image back to the spatial domain. The Discrete Cosine Transform, Discrete Fourier Transform Hartley transform etc. are orthogonal transform. The frequency domain perform operations on the image frequency content, so high frequency content like edges and other information can be easily enhanced. The frequency transformation is a straight forward transformation [3,5].

For example, medical image analysis, analysis of images from satellites etc. Image enhancement simply means, transforming an image f into image g using T. (Where T is the transformation. The values of pixels in images f and g are denoted by r and s, respectively. As said, the pixel values r and s are related by the expression, $s = T(r)$

II. RELATED WORK

Kale Vaishanw G (2014) [1] He has used the spatial filtering technique to improve the quality of the X-Ray Lung image". By improving the quality of a medical image it makes easy to detect the diseases for the physician because when the image is blurred, out of focus and noisy then it is difficult for physician to detect the diseases. So to solve this problem, the visual representation of the image is improved by image enhancement with the use of spatial filtering. In this paper the MSE and PSNR values are calculated to get parameter performance before and after the image result.

Neha Tripathi, Krishna Gopal Kirar (2014) [2] According to this paper a new method is introduced which is based on interpolation of high frequency sub-bands. This frequency is obtained from DWT and SWT. In proposed technique the DWT is used to decompose an image into different sub-bands and from them the images with high frequency sub-bands are interpolate. After that the interpolated sub-bands coefficients are corrected by using the high frequency sub-bands which are achieved by SWT of the input image. SWT & DWT are the method of image resolution enhancement. The sub-bands with lower frequency are interpolated with same interpolation factor. Then all the images are combined using DWT to generate a super resolved image. Further extra enhancement is done by the fusion provide image with better resolution diffusion. With this multicative noise is removed and the level of contrast is improved.

Sayed Hani Hojjati, Mohammad Reza hasseinzadeh, Ali Reihanian (2014) [3] According to this paper a new method is described to reduce the noise and improve the contrast of medical image. Here they proposed an algorithm which is used for this enhancement that is based on wavelet transformation. They firstly used the Haar transform to obtain the image's detail. Then Stationary Wavelet Transform (SWT) is used to remove the noise from the image. After that the image is enhanced by using different methods of image fusion. Finally Contrast Limited Adaptive Histogram Equalization (CLAHE). This algorithm improves the quality of an image after removing its noise. The experimental results of this paper indicates that the proposed method enhances the low quality images from different aspects such as contrast, visibility etc.

Tang Yong-Zheng (2014) [4] described that the result of a medical image is obtain in more accurate manner by fusion than other single medical image. He proposes a method of multi-focus medical image fusion based on improved redundant complex wavelet transform. The proposed multi-focus medical image fusion method integrates the pixel level fusion and some features level fusions. This method firstly decomposes multi-focus medical image fusion redundant wavelet transform (RWT). After that, to guide the organization coefficient it uses the extracted brink features. Finally RWT inverse transformation is use to reconstruct fusion medical image. With the employment of features for expressing the medical images, it doesn't only reduces only the complexity in the process but also enhance the stability of the fusion results. In this paper he has done experiment on several multi-focus medical images fusion & he has found that the method proposed by this paper shows better fusion effect as compare to gradient pyramid & non-consecutive wavelet transformations.

Diwakar Shrivastava, Dr. Vineet Richhariya (2014) [5] Here they described that the main key issue in high quality pictures such as digital cameras and image research area is image enhancement. When the image is acquired its clarity is easily affected by lighting or through other things that has been used to acquire image. With these conditions the image suffers from the poor contrast and noise. To reduce the noise and to improve the contrast of digital image they proposed a novel adaptive fuzzy contrast enhancement technique based on the fuzzy entropy principle and fuzzy set theory for low contrast grey scale images. This paper shows that the proposed algorithm is very effective and required minimum processing time as compare to other algorithm.

Kanwaljot Singh Sidhu, Baljeet Singh Kaira, Ishpreet Singh Virk (2012) [6] In this paper they used a wavelet technique to denoise the medical image. This technique works on Haar and Daubechies transforms. In this paper they have used the concept of hard & soft threshold. A wavelet technique is used to denoise the medical image. In this paper four different medical images MRI, Ultrasound, X-ray, CT scan are denoised using haar and db3 wavelets at both hard and soft threshold levels and the peak signal to noise ratio is calculated after denoising by both wavelet PSNR are compared is observed that db3 wavelet is more efficient than Haar wavelet for removing noise in medical images. It also enhance the visiual quality of medical images.

Umamaheswari, J. and G. Radhamani (2012) [7] They described that a DICOM image contain the multicative noise and when we enhance the image the multicative noise present in it is also enhanced. So they have proposed a hybrid

method which is used to improve the quality of digital images and communications in medicine (DICOM) image. This method improves the quality of image for early diagnosis. This new approach for DICOM image is implemented by using contrast stretching & anisotropic diffusion. With this the multicative noise is removed and the level of contrast is improved.

Qihong YE, Ming Xiang, Zhendong Cui (2012) [8] In this paper they proposed an algorithm for fingerprint image enhancement which is based on two dimensional Empirical Mode Decomposition (EMD) and Gabor filter. They firstly extended the one dimensional EMD into two dimensional EMD to process fingerprint image and to eliminate the bad impact of the noise on fingerprint image. In this paper they decompose the fingerprint image by BEMD algorithm. The IMF which are obtained after the decomposition represents a particular scale. IMF reflects image texture information at different scale. EMD technique is used to process fingerprint image. In this paper it is shown that this algorithm produce superior results as compare to traditional algorithms.

Lei WANG, Nian-de Jiang, Xing Ning (2012) [9] In this paper the research is done to make a medical image enhancement algorithm based on GSM model for wavelet coefficient . Firstly the Gaussian Scale Mixture (GSM) model denoise the image in auto-adapted wiener filter. This algorithm is used to denoise the medical CT image. Secondly the wavelet's approximate distribution and statistical characteristics are described through the qualitative analysis and classification of wavelet coefficients for the signal and noise. The results of this paper show that this algorithm improves the denoise result and enhance the medical image.

Shehal O. Mundhada et al.(2012)[10] They described that the image enhancement is a technique which is used to enhance the quality of image when any kind of image is acquire such as medical image , remote sensing image, electron microscopy etc, suffer from poor contrast the problem is solved by image enhancement. After the use of image enhancement methods the visibility and detail of images is increases. They proposed that the enhancement is done by using two techniques that are spatial domain and frequency domain. The spatial domain produces the undesirable results due to the altering of grey level values of individual pixels and overall contrast of the entire image. While wavelet transformation enhance easily the high frequency content such as edges and other suitable information.

III. PERFORMANCE PARAMETERS

MSE (Mean Square Error):

- MSE is the quality measuring parameter which is used over great extent. MSE helps to check the similarities between verage of square of error. Small value of MSE means small error of function used. For an image of size M*N the MSE is defined as

$$\mathrm{MSE} = \frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left(\left(\mathrm{f(x,y)} - \mathrm{fenh(x,y)}\right)^2\right)$$

RMSE (Root Mean Square Error):-

RMSE is also a quality examining metric of the image. It is obtained by taking the square root over mean square error (MSE).

$$RMSE = \sqrt{\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left((f(x,y) - fenh(x,y)\right)^2)}$$

PSNR (Peak Signal to Noise Ratio):-

PSNR is widely used quality metric.it is measured in logarithmic scale in decibles (db).By calculating the ratio of maximum signal power to maximum noise power we can find the PSNR value of the corresponding image. If the PSNR value of the image is increases, the quality of the image also increases gradually. []

$$\mathrm{PSNR} = \frac{\text{Max. Signal Power}}{Noise\ Power}$$

$$\mathrm{PSNR} = 10\log10\left(\frac{255^2}{MSE}\right)$$

High PSNR indicates about better reconstruction.

Structural Similarity Index:-

SSIM is a method for measuring in similarity between two images. Sim considers image degradation as perceived change in structural information.

$$SSIM = \frac{(2\mu x + C1)(2xy + C2)}{(\mu^2 + y^2 + c1)(\sigma^2 + \sigma^2 + C2)}$$

Comparison Table

Author	Operation Domain	Processing Technique	Purpose
Kale Vaishanw G [1]	Spatial Filtering	MSE- Mean Square Error PSNR- Peak Signal Noise Ratio	Improve brightness from medical image Remove noise from medical image Remove blurness from medical image

Neha Tripathi et al. [2]	Wavelet Transformation	SWT- Stationary Wavelet Transform DWT- Discrete Wavelet Transform PSNR- Peak Signal Noise Ratio SSIM- Structural Similarity Index	Give image with better resolution Better results in satellite & medical image
Seyed Hani Hajjati et al. [3]	Wavelet Transformation	Haar Transformation SWT- Stationary Wavelet Transform	Reduce Noise from medical image Improve the contrast of medical image
Tang Yong Zheng [4]	Wavelet Transformation	Image Fusion Method	Reduce noise from medical image Reduce redundancy from medical image
Diwakar Shrivastava et al. [5]	Fuzzy Set Theory Enhancement	Fuzzy Set Theory & Fuzzy Entropy Principle	Enhance the contrast This algorithm requires minimum processing time as compare to other algorithm
Kanwaljot Singh Sidhu et al [6]	Wavelet Transformation	Haar & DB3 Filtering PSNR- Peak Signal Noise Ratio MSE- Mean Signal Noise Ratio	Denoise the medical image Enhance the visual quality of medical image It helps in effective diagnosis
Umamaheswari et al. [7]	Contrast Stretching & Anisotropic Diffusion	MSE- Mean Square Error PSNR- Peak Signal Noise Ratio RMSE- Root Mean Square Error UQI- Universal Quality Index	Remove multicative noise from the medical image Improve the quality for early diagnosis
Qihong Ye et al. [8]	2-D EMD- & Gabor Filter	EMD- Empirical Mode Decomposition	Remove noise from the fingerprints image Improve quality of finger prints image
Lei Wang et al. [9]	Gaussian Scale Mixture Model for Wavelet Coefficient	AUTO-Adapted Wiener Filter	Denoise the medical CT image Improve the statical characteristics
Shehal O. Mundhada et al. [10]	Spatial & Wavelet Domain	MSE- Mean Square Error PSNR- Peak Signal Noise Ratio	Improve the brightness of medical image Denose the image

IV. CONCLUSIONS

In this paper we have been reviewed the existing techniques of image enhancement these techniques are classified into two categories that are spatial domain enhancement and wavelet or frequency domain based enhancement .These both techniques have their own benefits according to their features, but in medical image enhancement wavelet transformation performs better in many condition to enhance the quality of medical image. While spatial filtering has its own features for image enhancement. The spatial domain enhancement gives the moderate performance during the enhancement of the image. The spatial domains techniques are based on direct manipulation of the pixel in the image .The spatial domain techniques alter the gray level values of individual pixel and the overall contrast of the entire image. With this many times the undesirable result are obtained due to the enhancement of the image in uniform manner. While the wavelet domain performs operation on the frequency content of the image , so the enhancement of the high frequency content like edge and other suitable information can be done easily . Thus from this survey we concluded that wavelet transformation performs much better than spatial domain enhancement. The spatial domain has its own advantages. It also performs better in many conditions.

Our features work is the enhancement of medical image using wavelet transformation.

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