A Survey on Image Preprocessing Techniques for Diverse Fields of Medical Imagery

P. Vasuki
KLNCIT,Sivagangai
Tamilnadu,India
vasakime@gmail.com

J.Kanimozhi
KLNCIT,Sivagangai
Tamilnadu,India
kanimozhibalamurugan@gmail.com

M.Balkis Devi
KLNCIT,Sivagangai
Tamilnadu,India
balkisdevi19@gmail.com

***Abstract*- Image enhancement is one of the most important tasks in digital image processing. It is one of the most complex and important tasks in digital image processing. Image enhancement techniques are used in improving the visual quality of images. Medical Imaging is now recently used in most of the applications like Radiography, MRI, Nuclear medicine, Ultrasound Imaging, Tomography, Cardiograph, and Fundus Imagery and so on. Contrast and Image quality are the major problems in medical imagery. Image Enhancement makes the image clear for human perception or machine analysis. The process of Image enhancement doesn't raise the inbuilt information content of the data, but can highlight the features of interest to detect the objects in a simple and efficient manner.**

Keywords: Medical images, Enhancement, Digital X-Ray imagery, Mammogram imagery, Fundus imagery

I. INTRODUCTION

With the rapid increase of the application of Digital Imaging in the field of medicine, it has raised the need for the implementation of suitable algorithms for processing of Images in detection, Screening and classification of diseases. Medical images are affected by noise, blurriness and may suffer due to poor contrast and sharpness which may results in false diagnosis. Image Enhancement is the crucial task of medical image processing. There are different types of imaging techniques depending on the application it serves.

- X-ray methods of medical imaging include conventional X-ray, computed tomography (CT) and mammography.
- Molecular imaging uses a variety of methods to visualize biological processes taking place in the cells of organisms.
- Fundus imagery used to image the retina of eye in screening of Diseases like glaucoma and Diabetic Retinopathy.
- Other types of medical imaging include Magnetic Resonance Imaging (MRI), Cardiograph and ultrasound imaging.

II. IMAGE ENHANCEMENT

Image enhancement techniques can be divided into two broad categories:

A. Spatial Domain Enhancement Method

Spatial Domain techniques are used to denote techniques that perform manipulation operation on Individual pixels of an image. It includes point arithmetic operations and Neighborhood enhancement algorithms.

Point arithmetic operations include gray-level transformation and histogram equalization. Gray-level transform includes linear, logarithmic and power law transformation. The linear Transformation may result in Identity or Negative transformation of an image. Logarithmic transformation may expand the darker pixels of an image and higher values are compressed which yields an enhanced image. power law transformation may include n-th root or n-th power transformation. The degree of enhancement may be adjusted depending on the value of n.

Histogram equalization may ensure the uniform distribution of gray levels, but major drawback is that it cannot highlight the edges of the image and cannot be applied to detection Applications.

Neighborhood enhancement algorithms include image smoothing and image sharpening. The Image Smoothing is used to eliminate image noise and Image sharpening emphasizes the edges, but reduces the Contrast of the Image.

B. Frequency Domain Enhancement method

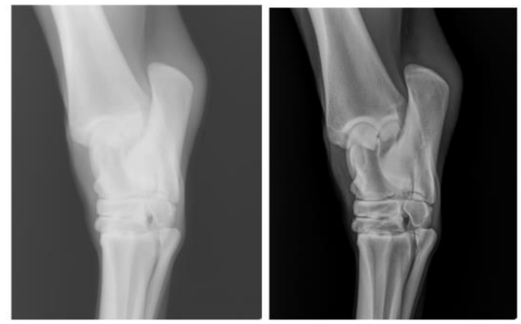
In frequency Domain we compute the Fourier transform of an image and multiply the result by a filter and take the Inverse Fourier transform to obtain the original Enhanced image. The frequency domain method includes low-pass filtering, high-pass filtering and homomorphic filtering. In Low pass-filtering high frequency components are eliminated and low frequency components are retained. Typical filters are Butterworth low pass filters which can remove the sharp transitions associated with noise and thus may denoise the image and preserve the information.

Similarly high pass filters may remove low frequency components and preserve the high frequency components and homomorphic filters may be used to extract illumination and reflectance components from the image. However in the case of medical images, the above specified methods process whole image, and may hide both partial and specific information and thus can be interfered by the noise easily. Therefore, it cannot meets the requirements of the medical image processing.

III. PREPROCESSING OF DIGITAL X-RAY IMAGES

X-Ray images are being used to image the internal structure of human body. In X-Rays an X-Ray beam passes through the body. When it passes through the body, the part of the energy of the X-Ray beam gets absorbed which is called attenuation.[7] At the other end detectors capture the attenuated X-Rays producing a clinical image. The types of X-Rays are Computed-Tomography (CT), mammography, Angiography and fluoroscopy.

X-Rays are one of the widely used diagnostic tools in medicine. They are used to check for the extent and type of bone fractures and other pathological related abnormalities. The main Disadvantage with X-Ray images is its low contrast and they get corrupted by additive noise. Gaussian noise, Poisson noise are regarded as additive noises[7] and denoising models are developed on the basis of these noise models. The reason for reduced contrast and noise in X-Ray images is due to the presence of bulk amount of liquid in human body.



(a) (b)

Fig. 1. (a) and (b) shows the raw image and preprocessed image respectively.

Preprocessing in X-Ray images generally denote the denoising of images. If enhancement algorithms are applied without denoising then they may greatly amplify the noise and may cause loss of Information in Images. Therefore denoising may be performed using suitable filters.

A. LITERATURE REVIEW

In X-Ray images in order to remove the noise effectively without losing Image features, variance stabilization called Gaussianizing [7] is performed. Different authors have proposed different algorithms for the problem of variance stabilization.

The first method was called Anscombie Variant stabilizing Transform proposed by donoho in 1993.In 1995 Murtagh et al proposed a Generalized Anscombie Transform (GAT) which is used to achieve a stabilized standard deviation and variance.

PURELET is another denoising method developed by Luisier et al (2010). This method produces an estimate of MSE between the original and denoised image and makes an effort to reduce the MSE value in order to obtain an enhanced image.

Gilboa et al(2004) developed an gradient based method by combining free space equation with the schrodinger equation. This method is useful in the cases of sharp detection of edges. However this method suffers from a disadvantage that it is sensitive only to Gaussian noise.

After denoising the image may be contrast enhanced by Adaptive Histogram Equalization (AHE)[1] or Contrast adapted Histogram equalization (CLAHE). In mathematical terms, a histogram h(ri) is expressed as:

$$h(r_i)=n_i \text{ for } i=0,1,2....L-1$$

- ri is the ith gray-level in the image for a total of L gray values and
- ni is the number of occurrences of gray-level ri in the image.

These algorithms may highlight the seed points in X-Ray images after denoising and may achieve accurate results through detection of points of interest from image. Adaptive Histogram Equalization overcomes the limitations of global histogram equalization by providing most of the desired information in a single image which can be produced without manual intervention. This approach makes the method more effective for both grey scale and color Images.

DATABASES

- ECLAP(CT-Chest Images)
- VOLCANO'09(Lung database)
- LITFL(Radiology Image Databases)

IV. X-RAY MAMMOGRAPHY

Mammography is one of the medical imaging technologies that use low-dose x-rays to detect Breast cancers. Digital mammograms are one of the most challenging areas in medical imaging. Image pre-processing is used in digital mammographic Images in order to distinguish differences between tissue types due to the low image quality of mammogram images. Mammograms can detect any abnormalities with minimum amount of absorbed dose to the breast.

Image quality of the mammogram images is affected due to the presence of unknown noise, poor image contrast, Homogeneity and poor boundaries.

A. DENOISING

Filters may be implemented to reduce the noise and high frequency components. Averaging filter can replace the value of pixels at each point with the average of the pixels in the neighborhood. However it blurs out the image and reduces the accuracy of feature extraction. [8] Median filtering can remove noise and increases the sharpness of the image. It is effective in removing salt and pepper noise and the degree of sharpness of image after filtering may depend upon the size of the filter used in median filtering. Adaptive median filter is an enhancement of median filtering which operates on rectangular neighborhood region. It operates on rectangular neighborhood replacing the center value with the median of the neighborhood value of the rectangle. It does not blurs out the edges and is specially suited for mammogram Images.

Wiener filter is used to reconstruct an enhanced image[8] similar to the original image by reducing the MSE(Mean Square Error).By forcing the MSE to zero the enhanced image has all the features of the original image. A wiener filter can reduce noise and enhance the image simultaneously and can be adopted for mammogram images.

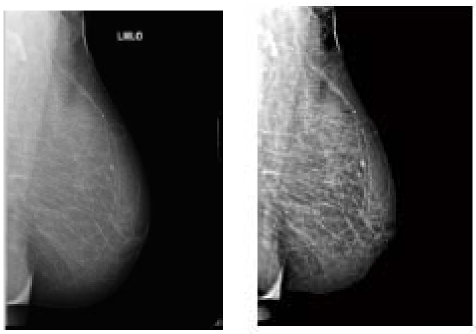
B. IMAGE ENHANCEMENT

The need for Enhancing mammograms is for the precise segmentation of breast region for automated analysis of digital mammogram images. It can eliminate background noise and improve the image quality for the purpose of determining the region of interests (ROI) in the image. The process of image enhancement can be done by Histogram equalization[8] which may be global or local depending on the type of features to be extracted. Hoyer.A (1979) proposed a method of local thresholding based on histogram equalization, while Yin.F (1991) proposed a method of global thresholding on histogram equalization.

(a) (b)

Fig. 2. (a) and (b) shows the original and enhanced image by histogram equalization

The morphological operations are applied on the grayscale mammography images to segment the abnormal regions. Bick.U (1995)[11] proposed a enhancement method based on histogram equalization, Region growing and morphological operations. However a major drawback of the mathematical morphology technique is that a part of the noise still remains.



(a) (b)

Fig. 3. (a) and (b) shows the original image and enhanced image by morphological operations[13]

Gradient based methods may be used in the case of extraction of edges. Semmlow.J (1980) proposed a gradient based method based on sobel operator for the detection of edges. However modern methods may use canny, prewitt or other edge detection operators with suitable denoising techniques.

DATABASES

- DDSM(Digital Database for Screening Mammography)
- OPTIMAM image mammography database
- Mini-MIAS

V. FUNDUS IMAGERY

Color Fundus Retinal Photography uses fundus cameras to record color images of the interior surface of the eye, for the process of detection of presence of disorders and to monitor their changes over time.

Digital fundus images (DFIs) are used to image the retina, optic disc, macular regions and the posterior surface of an eye. These regions are used by ophthalmologists for diabetics screening for grading of diabetic retinopathy (DR).There are a few characteristics in fundus images which are used in characterization of DR such as exudates, micro aneurysms, hemorrhages and blood vessels. Detection and grading of Diabetic Retinopathy is based on the identification of these features in fundus images. Regular diabetic eye screening is an important step in detecting and screening of DR.

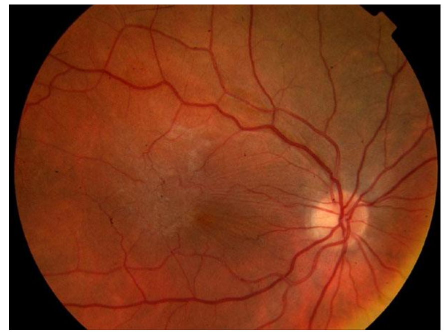


Fig. 4. Retinal fundus image

FUNDUS IMAGE DATABASES:

- DRIVE
- STARE
- MESSIDOR
- DIARETDB0
- DIARETDB1

A. DENOISING

Speckle noise is one of the major problems in medical images. It arises due to the multiplication of certain unwanted signal with the original signal resulting in reduction of image information and quality. In fundus images only LRF (Low Resolution Fundus) Images suffer from noise. High Resolution Fundus Images have zero noise as they are captured through highly specialized cameras. Noise removal technique in LRF Images has been discussed.

Noise removal may be performed either in spatial or frequency domain. Though most of the medical images require denoising in frequency domain, filtering in spatial domain is suitable for fundus images because they require the need of sharp detection of edges. Non-linear filtering may be used for fundus images. Though this may require consistent processing time, it achieves better results as compared to linear filtering and preserves image information Therefore spatial non-linear filtering techniques like mean filter, wiener filter, Gaussian filter, median filter may be used for effective noise removal while preserving the edges in fundus images.

B. IMAGE ENHANCEMENT

Image enhancement is used to improve the visual effects and the clarity of image or to make the original image more conducive for computer to process. It involves collection of techniques to improve the visual appearance of an image for analysis by a human or machine. It can improve the image appearance by increasing dominance of certain features and decreasing ambiguity between different regions of the image.

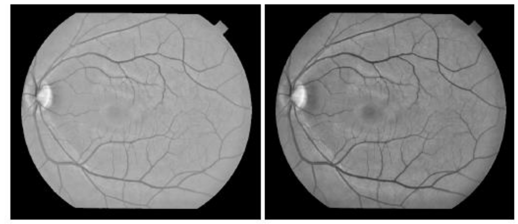
The features in retinal fundus images are optic disc, blood vessels, lesions and exudates. Each of these features have different color identifications and different contrast features which makes its detection possible in various channels. In general for the detection of blood vessels and lesions green channel of the fundus image is used, as the blood vessels appear brighter in the green channel of the fundus image. for the process of detection of optic disc for glaucoma screening red channel is used as it appears brighter in red channel as compared with the blue and green channels. Blue channel is mostly not used with fundus image processing as no information can be extracted from blue channel of fundus image.

ILLUMINATION EQUALIZATION

The illumination in a retinal image is non-uniform due to the variation of the retinal response or the non-uniformity of the imaging system.Due to uneven illumination the OD may appear darker than other retinal regions and to overcome the non-uniform illumination, each pixel is adjusted (equalized) using the following equation .

$$I_{eq}(r, c) = I(r, c) + m - I_w(r, c)$$

Where 'm' is the desired average intensity and $i_w(r,c)$ is the mean intensity value of the pixels within a window of size N X N. In the following image the vessel and optic disc region gets highlighted after enhancement as compared to the original image.



(a) (b)

Fig 5 (a) and (b) shows the original image and enhanced image after illumination equalization.

CONTRAST LIMITED ADAPTIVE HISTOGRAM EQUALIZATION (CLAHE)

Contrast Limited Adaptive Histogram Equalization (CLAHE) uses RGB color images directly and by this method[14], the noise content of an image is not excessively enhanced resulting in contrast enhanced image.

(a) (b)

Fig 5 (a) shows an input image and (b) shows an enhanced image by CLAHE

ENHANCEMENT BASED ON DIRECTIONAL FIELD

Directional field enhancement includes, the estimation of directional field and Image enhancement. The enhancement is made along the vascular direction and brightness is normalized in each step. After estimating the directional field, the mean and variance values in a local neighborhood are calculated pixel-by-pixel, and accordingly local neighborhood is normalized and enhanced. This method can obviously increase the contrast of retinal vessels.

VI. CONCLUSION AND DISCUSSIONS

Medical diagnosis is possible only by means of medical imaging .Life threatening diseases like cancer are now being treated only through medical scanning images. A brief survey has been presented on the preprocessing techniques of X-Ray, mammogram and Fundus images. Each section has been elaborated with denoising and enhancement techniques used for the particular type of image. The survey shows that each image differs in the image quality and contrast depending on the capturing technique. X-ray and mammogram images may require denoising and enhancement while fundus images may require only enhancement due to its highly specialized photographic techniques and the need for image information preservation. This paper can provide a clear idea on preprocessing of images for the further steps on image processing.

References

1) Dr. Krishna Mohanta, Dr.V.Khanaa "An Efficient Contrast Enhancement of Medical X-Ray Images- Adaptive Region Growing Approach" International Journal Of Engineering And Computer Science,2013, Volume 2 Issue 2,pp 386-390.

2) Priya Thamman, Rekha Bhatia "A New Methodology for Improvement of Contrast to Show Fractures in X-ray Images" International Journal of Computer Science and Information Technologies,2014,volume 5,pp 6400-6403.

3) D.Narain Ponraj, M.Evangelin Jenifer, P. Poongodi, J.Samuel Manoharan" A Survey on the Preprocessing Techniques of Mammogram for the Detection of Breast Cancer" Journal of Emerging Trends in Computing and Information Sciences,2011

4) Mr. Salem Saleh, Dr.N.V.Kalyankar, Dr.S.D.Khamitka "Linear and Non-linear Contrast Enhancement of images" International Journal of Computer Science and Network Security,2010

5) Aziz Makandar ,Bhagirathi Halalli "A Review on Preprocessing Techniques for Digital Mammography images" International Journal of Computer Applications,2015

6) Husna Ab Rahim, Ahmad Syahir Ibrahim, W Mimi Diyana W Zaki, Aini Hussain "Methods to Enhance Digital Fundus Image for Diabetic Retinopathy Detection" IEEE 10th International Colloquium on Signal Processing & its Applications,2010

7) S. Hosseinian, H. Arefi, " Assessment Of Restoration Methods Of X-Ray Images With Emphasis on Medical Photogrammetric Usage", The International Archives of the Photogrammetric, Remote Sensing and Spatial Information Sciences, 2016, XXIII ISPRS Congress, 12–19 July 2016

8) R. Ramani, Dr. N.Suthanthira Vanitha, S. Valarmathy"The Pre-Processing Techniques for Breast Cancer Detection in Mammography Images" International Journal of Image, Graphics and Signal Processing, 2013, Volume 5,pp 47-54

9) Sara Dehghani ,Mashallah Abbasi Dezfooli "A Method to Improve Preprocessing Images in Mammography "International Journal of Information and Education Technology, April 2011,Vol. 1.

10) Hoyer, A.Spiesberg, "Computerized mammogram processing for detection of breast cancer" Phillips Technical Review,1979,volume 38,pp 347-355.

11) Bick. U, Giger.M" Automated segmentation of digitized mammograms" Academic Radiology ,1995,Volume 2,pp 1-9

12) Semmlow.J, Shadagopappan.A," A fully automated system for screening xero-mammograms" Journal of Computers and Biomedical Reseach,1980,Volume 13,pp 350-362.

13) Saeed Setayeshi , Ali Reza Karimian, Mehri Sirous , Mohammad Esmaeil Akbari, "Comparing the Performance of Image Enhancement Methods to Detect Micro calcification Clusters in Digital Mammography" ,2012, volume5, springer, pp 61-68

14) L.Seoudetal.,"Automatic detection of micro aneurysms and haemorrhages in fundus images using dynamic shape features," inProc.IEEE,11th Int. Symp .Biomed. Imag., Beijing,2014,pp.101–104.