ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

REVIEW OF VARIOUS MEDICAL IMAGE ENHANCEMENT TECHNIQUES FOR EARLY DETECTION OF CANCER

VIDYASARASWATHI H N
Assistant Professor
Dept. of ECE, Bangalore Institute of Technology
K.R. Road, Bangalore Karnataka,India
vidya.gowdaec@gmail.com

HITHAISHI DEVARAJ
Assistant Professor
Dept. of ECE, Bangalore Institute of Technology
K. R. Road, Bangalore
Karnataka,India
work.hithaishi@gmail.com

JANARDHAN R
Assistant Professor
Dept. of ECE, Bangalore Institute of Technology
K.R. Road, Bangalore Karnataka ,India
janardhanrangappa@gmail.com

NAGENDRA KUMAR M
Professor
Dept. of TCE, SJCIT
Chickballapur
Karnataka ,India mnagendrakumar72@gmail.com

ABSTRACT

Image enhancement is a processing on an image to make it more suitable for some applications. The main problem ad-dressed by this paper is the enhancement of medical images using efficient algorithms based on HE (Histogram Equal-ization) techniques such as Iterative dynamic HE, Dualis-tic sub-image HE, Background brightness preserving HE, Gray-level and gradient magnitude HE. The paper involves analyzing and formulating different HE image enhancement techniques suitable for various medical applications captured under poor illumination conditions, foggy situations and speckle noise etc. Developing algorithms that would assist doctors to diagnose the disease in the beginning stage only, example removal of speckle noise and artifacts with segment-ing kidney from those images where kidney boundary are not much clear. For improving the performance of image processing systems the crucial solution is implementation of image processing techniques in hardware. And also for flexi-ble design development, more compact, low power, and high speed and to reduce cost and time, gives the implementation of efficient histogram algorithms on FPGA.

Categories and Subject Descriptors

I.4 [Computing Methodologies]: Image Processing & Computer Vision; I.4.3 [Enhancement]: [Gray Scale Manipulation]

General Terms

Algorithms

Keywords - Image enhancement, histogram equalization,Breast cancer, FPGA(Field Programmable Gate Array), contrast enhance-ment.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

I. INTRODUCTION

Cancer is a group of diseases that cause cell in the body to change and grow out of control. In the human body, new cells are formed and old cells are dying out day-to-day. Sometimes new cells are produced, grow uncontrollably and form abnormal cell structure called tumour cells. Most types of cancer cells eventually form a tumour and are named after the part of the body where a tumour originates.

Breast cancer is a type of cancer originating from breast tis-sue, most commonly from milk ducts and the lobules. Milk ducts are the tubes that carry milk to the nipple and lob-ules are the glands that make milk. While the majority of human cases are in women, breast cancer can also occur in men as well. The primary cause of breast cancer is ageing. Other potential risk factors include genetics, lack of breast-feeding, higher levels of certain hormones, obesity, certain dietary patterns, hereditary, etc. Habits of tobacco, smok-ing and drinking alcohol are some of the other reasons for being affected by breast cancer. Breast cancer is the second leading cancer in women. As per Survey Report of Ameri-can Cancer Society in 2013, one in eight women is affected by breast cancer in their lifetime [15]. Breast cancer diagno-sis has become the need of the hour and detection of breast cancer at the early stage will be a major boon to reduce the mortality rate.

Breast image capture and analysis techniques play a ma-jor role in detecting breast cancer. Some of the medical diagnostic methods for breast cancer include Mammogram, Ultrasound and MRI. Mammograms are usually used as a screening test, while ultrasound is usually done for diagnos-tic reasons. MRI test helps to find how large cancer is and suspected muscles are underlying, but it is a litter too ex-pensive. The best way to identify the presence of breast can-cer at an early stage is by interpreting mammogram images.

Though mammography is an effective screening tool used by the radiologist for detection of breast cancer, it is difficult for the radiologist to interpret the results from mammograms as mammograms generally have low contrast. Double reading of Mammogram leads to increase in the cost of detection. Also, factors such as reading visually and interpreting mam-mograms are considered as a complex task for radiologists. Their judgments essentially depend on training, experience and other subjective parameters. The Computer Aided Di-agnosis (CAD) tools have been developed to complement radiologists in mammogram analysis to identify the differ-ent forms of tumours or masses which may be harmful. The combination of CAD scheme and experts knowledge of ra-diologists would improve the detection rate of breast cancer in early stages and thereby improve survival rate.

For a CAD system to work efficiently and classify mammo-gram to normal and abnormal, a series of image processing techniques need to be applied on the digital Mammogram. These include pre-processing, image enhancement, feature extraction and classification. Image pre-processing is very important in order to find the orientation of the mammo-gram, to remove the noise, identify the region of interest and to enhance the quality of the image. Digital mammo-gram images contain artefacts in the form of labels, wedges, and markers in the background region. The mammogram pre-processing stage involves noise removal and artefact sup-pression in order to suppress the background in the mam-mogram images. Also, Image segmentation is done to obtain the region of interest. Image enhancement is a crucial step in most of the image processing applications. Enhancement means improving the visual quality of image for better in-terpretation and human perception. The Feature extraction is the process of transformation of an image into a set of fea-tures. Most prominent features are extracted which give the property of the image and are compared with the features of unknown sample Image for classification. Due to the hetero-geneous nature of the mammogram, a general classification approach may not be adequate to classify mammogram into a normal and abnormal pattern. An efficient classifier with high accuracy needs to be developed for this purpose. The classification process includes both training and testing of data sets. First, the classifier will be trained on the fea-tures extracted from training data set. Further testing can be done on the test mammogram images. In early days, re-searchers collected the real-time image from various places and hospitals. Nowadays, in addition to images from hospi-tals, medical images are also available online. All of these images can be easily accessed and used for research pur-poses. Mammogram Image Analysis Society (Mini-MIAS Database) and Digital Database for Screening Mammogram (DDSM Database) are two such online databases that can be used freely for research purposes. For accurate classification of mammograms, the need is to design a robust algorithm that can work optimally at each stage of pre-processing, en-hancement, feature extraction and classification. [7] proposed a system which can achieve a higher throughput and higher energy efficiency. The S-BOX is designed by using Advanced Encryption Standard (AES). The AES is a symmetric key standard for encryption and decryption of blocks of data. In encryption, the AES accepts a plaintext input, which is limited to 128 bits, and a key that can be specified to be 128 bits to generate the Cipher text. In decryption, the cipher text is converted to original one. By using this

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

AES technique the original text is highly secured and the information is not broken by the intruder. From that, the design of S-BOX is used to protect the message and also achieve a high throughput, high energy efficiency and occupy less area.

II. CONVENTIONAL IMAGE ENHANCEMENT TECHNIQUES

2.1 Histogram Equalization (HE)

Histogram equalization is widely used for contrast enhancement in a variety of applications like computer vision, remote sensing, medical image analysis etc., due to its simple function and effectiveness. It works by using the cumulative density function of the image by flattening the histogram and stretching the dynamic range of the gray levels. One problem of the histogram equalization is that the brightness of an image is changed after the histogram equalization.

2.2 Band Limited Histogram Equalization (BLHE)

Naglaa S Ali Ibrahim et al. [8], proposed an algorithm for the automatic removal of artefacts and noise that are present in mammogram images using morphological operations, and then Band Limited Histogram Equalization (BLHE) is used to enhance contrast of mammogram images for easier detec-tion of lesions or tumours. After pre-processing of mammo-gram images, Otsu's N thresholding method is deployed to detect the region of interest. This technique carries a flaw, because mammograms usually contain low intensity pixels (less than 18 gray scale) near skin air interface, therefore, segmentation of breast region by fixing the gray scale inten-sity level may over segment the breast region.

2.3 Adaptive HE Technique(AHE)

AHE differs from the normal HE method in the respect that HE generates only one histogram whereas AHE method computes several histograms corresponding to a distinct sec-tion of the image and uses that to redistribute the intensity values of the image. By using ADE method can improve the detection of spiculations on dense mammographic back-grounds. Saeid et al.[3], proposed an adaptive HE method for segmentation of blood vessels in color retinal images.In this method, focus on two methods of retinal vessel segmen-tation including first derivative of Gaussian matched filter and Gaussian matched filter. AHE improves the image con-trast to enhance the image quality of retinal vessels used in diagnosis of diseases such as diabetes and high blood pres-sure. This method showed an accuracy of 0.9353 a raise of about 2 percent compared to existing methods. Analysis of this approach shows that AHE method used in retinal vessel segmentation is based on threshold. Therefore, this approach is suitable for specific type of images.

2.4 Contrast Limited Adaptive Histogram Equal-ization (CLAHE)

Ranjit Biswas et al.[1], proposed an automated CAD system to classify the breast tissues as normal or abnormal. Artefacts are removed using ROI extraction process and noise has been removed by the 2D median filter. Contrast-Limited Adaptive Histogram Equalization (CLAHE) algorithm is used to improve the appearance of the image. The texture features are extracted using Gray Level Co-occurrence Matrix (GLCM) of the region of interest (ROI) of a mammogram. The standard Mammographic Image Analysis Society (MIAS) database images are considered for the evaluation. K-Nearest Neighbor (KNN), Support Vector Machine (SVM) and Artificial Neural Network (ANN) are used as classifiers. For each classifier, the performance factor such as sensitivity, specificity and accuracy are computed. It was observed that the proposed scheme with 3NN classifier outperforms SVM and ANN by giving 95 percent accuracy, (SVM) and Artificial Neural Network (ANN) are used as classifiers. For each classifier, the performance factor such as sensitivity, specificity and accuracy are computed. It was observed that the proposed scheme with 3NN classifier outperforms SVM and ANN by giving 95 percent accuracy, 100 percent sensitivity and 90 percent specificity to classify mammogram images as normal or abnormal. This work was tested for 20 images. In future the number of test images can be increased considerably. Here a total of four features were given to the classifier, as a future work more features can be added for better accuracy.

Shibin et al.proposed a new algorithm for feature and contrast enhancement of mammographic images based on multiscale transform and mathematical morphology. In this algorithm the Laplacian Gaussian pyramid transform is ap-plied first to decompose the mammography into different multiscale subband sub-images. Further the detail or high frequency sub-images are equalized by using the Contrast Limited Adaptive Histogram Equalization (CLAHE) and low frequency sub-images are processed by using mathemat-ical

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

morphology. Finally, the enhanced image of feature and contrast is reconstructed from the Laplacian Gaussian pyra-mid coefficients modified by using CLAHE and mathemat-ical morphology. Therefore, the performance evaluation of the this algorithm is based on, signal-noise-ratio (SNR) and contrast improvement index (CII). And the research result shows the algorithm yield better image contrast compared to AHE.

2.5 Dense scale invariant feature transform(DSIFT)

Nasrin Tavakoli et al. [6], proposed a classification method based on sparse learning to diagnose breast cancer in mammograms. For this purpose, a supervised discriminative dictionary learning approach is applied on dense scale invariant feature transform (DSIFT) features. A linear classifier is also simultaneously learned with the dictionary which can effectively classify the sparse representations. The proposed method shows a sensitivity of 92.37 percent. In future, this method can be improvised by including other parameters such as accuracy and specificity to build a Computer-Aided Diagnosis (CAD) system to help radiologists diagnose breast cancer more accurately.

2.6 Brightness Preserving Dynamic Histogram Equalization (BPDHE)

In BPDHE method the original image is decomposed into multiple sub images according to their local maxima, then the dynamic histogram equalization is applied to each sub image and finally, the sub Images are combined. It divides the histogram based on the local maxima. It produces the output image with the mean intensity almost equal to the mean intensity of the input, thus fulfils the requirement of maintaining the mean brightness of the image. This method smoothes the input histograms with one dimensional Gaussian filter, and then partitions the smoothed histogram based on its local maxima. After that it assigns new dynamic range to each partition. Then, the histogram equalization process is applied independently to these partitions, based on this new dynamic range and the output image is normalized to the input mean brightness. Nungsanginla et al. [17], provided an analysis and comparison of the various techniques of image enhancement through histogram equalization are overviewed. The result is that Brightness preserving Dynamic Histogram Equalization (BPDHE) technique provides better and scalable brightness preservation for images with poor contrast. The advantage of BBPHE is it allows higher level of brightness preservation to avoid unwanted noises.

2.7 Dispersed Region Growing Algorithm (DRGA)

Ayush Shrivastava et al. [14], proposed a methodology for removal of labels, annotations and tags from the mammo-graphic image using morphological opening method. Sliding Window Algorithm (SWA) is used for removal of pectoral. After removing the pectoral muscle, Dispersed Region Grow-ing Algorithm (DRGA) is used for segmentation of mammo-gram which disperses seeds in different regions instead of a single bright region. The proposed method shows a accu-racy of 91.3 percent. The seed selection in region growing method is commonly neglected which has been given im-portance in this segmentation method. In future, machine learning techniques can be applied to automatically learn hyper parameters as used in SWA and DRGA for different categories of mammograms and further classifying them into abnormal and normal classes.

2.8 Sharp Contrast Limited Adaptive Histogram Equalization (SCLAHE)

Siti et al. [12], study on the identification of dental abnormalities in intra-oral dental radiographs. The abnormalities are Periapical Radiolucency (PA), widen periodontal ligament space (widen PDLs) and Loss of Lamina Dura (Loss of LD). Image processing techniques such as Contrast enhancement algorithms (CEAs) are accepted in dentistry in enhancing digital dental radiographs and assisting the dentists during interpretation process. Thus, it compares the performance between original images and the images enhanced by CEAs. The algorithms are Adaptive Histogram Equalization (AHE), Contrast Limited Adaptive Histogram Equalization (CLAHE) and Sharp Contrast Limited Adaptive Histogram Equalization (SCLAHE). The researchers mentioned that the future work will be conducted to focus on further investigation on the gray scale properties of the images that contribute in detecting the abnormalities.

III. RELATED WORK

Breast cancer is most common cancer in women. Due to the low contrast nature of mammographic images it is compli-cated to identify signs such as bilateral asymmetry, archi-tectural distortion and masses etc [1]. Here Adaptive HE technique (AHE) is used to differentiate between benign or malignant tissues.AHE differs from the normal HE method in the respect that HE generates only one histogram whereas AHE method computes several histograms corresponding to a distinct section of the image and uses that to redistribute the intensity values of the image [9]. In [12], by using ADE method can improve the detection of speculations on dense mammographic backgrounds. This is better enhancement method for medical images and also

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

incorporates histogram modifications as an optimization technique, but produces noise over amplification. For that reason have to extract more features of mass and classify to identify benign or ma-lignant patients for early recognition of syndrome by using other techniques.

In recent years ultrasound images used as imaging modalities to detect and diagnose human organ and tissue related disor-ders like to early detection of kidney disorders and diseases, but due to the presence of speckle noise and low contrast in ultrasound imaging detection of tissues and also to detect structural abnormalities becomes difficult. In [11], proposed a method to develop and implement a system that can seg-ment human kidney from ultrasound images, usable during surgical operations like punctures but this method is not suitable when image boundary is not clear. Therefore work includes removal of speckle noise and artifacts with segment-ing images where image boundaries are not much clear by using different segmentation techniques. Ultrasound images have poor contrast due to the presence of granular speckle noise. In [13], proposed algorithm aims to improve the ability to differentiate between healthy and malignant conditions via the use of homomorphic filtering and Otsuˆ aAZs gray-level histogram thresholding. Homomorphic filtering is based on its principle of reducing the dynamic range and thereby increasing the local contrast. But this method loses some of the image texture. Therefore to improve trade-off between image contrast and resolution in context of preser-vation of textural information and reduced blurring of sam-ple the HE algorithms can be adopted.

IV. METHODOLOGY

4.1 Automatic Histogram Equilization usingGMM

In this work, a new HE-GMM method is proposed for con-trast enhancement. Proposed method not only preserves original image brightness but also enhances contrast and vi-sualization of original image while without over-enhancement. Although previous extensions of GHE can preserve image brightness, depending on the characteristics of the image, they can either overdraw or fail to enhance image contrast and visualization. HE-GMM eliminates these problems with-out undesirable artifacts and works effectively.

4.2 Iterative Dynamic HE technique

In [2], the iterative sub-histogram equalization method is proposed, that helps to enhance better contrast than any other brightness preserving enhancing techniques.

4.3 Dualistic Sub Image Histogram Equalization (DSIHE)

Dualistic sub-image histogram equalization (DSIHE) also separates the input histogram into two subsections. DSIHE chooses to separate the histogram based on gray level with cumulative probability density .The result of the dualistic sub-image histogram equalization is obtained after the two equalized sub images are composed into one image. Bright-ness Bi-Histogram Equalization (BBHE) BBHE method is used to decompose the original image into two sub-images, by using the image mean gray-level, and then apply the HE method on each of the subimages. The BBHE method pro-duces an output image with the value of brightness (mean gray-level) located in the middle of the mean of the input image. The BBHE technique is a hybrid method between mean brightness preserving histogram equalization methods with clipped histogram equalization method. This technique can enhance the images without producing unnecessary arti-facts. Therefore, by applying these techniques the problems explained in section 3 is overcome.

V. CONCLUSION

The main problem addressed by this paper is the enhance-ment of medical images using efficient algorithms based on HE techniques. The proposed research involves analyzing and formulating different HE image enhancement techniques suitable for various medical applications. More precisely, proposed research will focus on the enhancement of medical images captured under poor illumination conditions, foggy situations and speckle noise. Therefore design of algorithm for histogram based medical image enhancement using the techniques Iterative Dynamic HE, DSIHE, and BBHE can overcome the problems explained in section 3 which include the applications breast cancer, kidney diseases etc. Devel-oping algorithms that would assist doctors to diagnose the disease in the beginning stage only. For example the removal of speckle noise and artifacts with segmenting kidney from those images where kidney boundary are not much clear. For improving the performance of image processing systems the crucial solution is implementation of image processing tech-niques in hardware. Also for improving the performance of image processing systems, for flexible design

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 3, January 2018

development, more compact, low power, and high speed and to reduce cost and time, gives the implementation of efficient histogram al-gorithms on Field Programmable Gate Array (FPGA) with pipelining and parallel processing.

REFERENCES

[1] Ranjit Biswas, Abhijit Nath and Sudipta Roy, aˆAIJMam-mogram Classification using Gray-Level ooccurrence Matrix for Diagnosis of Breast CancerˆAI, 2016 International Con-ference on Micro-Electronics and Telecommunication Engi-neering.

[2] Ping Hsien, Chih-Tsung Shen, ”Contrast enhancement on color images using iterative histogram rearrangement”, 13th IEEE international symposium on consumer electronics.

[3] SaeidFazli, SevinSamadi, ParisaNadirkhanlou, ”A novel retinal vessel segmentation based on local adaptive histogram equalization”, 2013 8th Iranian Conference on Machine Vi-sion and Image Processing.

[4] Tarun Kumar Agarwal, Mayank Tiwari, Subir Singh Lamba, ”Modified histogram based contrast enhancement using ho-momorphic filtering for medical images”, 2014 IEEE.

[5] Senthilkumaran N, Thimmiaraja J, ”Histogram equaliza-tion for image enhancement using mri brain images”, 2014 World Congress on Computing and Communication Tech-nologies.

[6]Nasrin Tavakoli et al, aˆAIJAbnormality Detection of Mam-mograms by Discriminative Dictionary learning on DSIFT DescriptorsˆaAI, 2017 IEEE, 978-1-5090-2809-2.

[7] Christo Ananth, H. Anusuya Baby, “S-Box using AES Technique”, International Journal of Engineering Research & Technology (IJERT), Vol. 3 Issue 3, March – 2014, pp 285-290

[8]Naglaa and segmentation of mammogram imagesˆAI, 2016S Ali Ibrahim et al, ˆAIJAna algorithm for pre-processing IEEE, 978-1-5090-3267-9..

[9]Shelda Mohan, M. Ravishankar, ”Modified Contrast Lim-ited Adaptive Histogram Equalization Based on Local Con-trast Enhancement for Mammogram Images”, 2013.

[10]Mengxu Chen, Junfeng Wang, Tianyi Zhan, ”Mammo-grams contrast enhancement based on background homoge-nization”, Shanghai JiaoTongUniversity,Shanghai, China 2013 IEEE.

[11]Tanzila Rahman, Mohammad Shorif Uddin, ”Speckle Noise Reduction and Segmentation of Kidney Regions From Ultra-sound Image”, Jahangirnagar University 2013 IEEE.

[12] Etta D.Pisano, Shuquan Zong, Bradley M. Hemminger, Marla DeLuca, R.Eugene Johnston, Keith Muller, M. Pa-tricia Braeuning, and Stephen M.Pizer, ”Contrast Limited Adaptive Histogram equalization Image processing to Im-prove the detection of Simulated Spiculations in Dense Mam-mograms”, Journal of Digital imaging,1998.

[13]Dhinagar, Nikhil J., and Mehmet Celenk. ”Ultrasound medical image enhancement and segmentation using adap-tive homomorphic filtering and histogram thresholding.” In Biomedical Engineering and Sciences (IECBES), 2012 IEEE EMBS Conference on, pp. 349-353. IEEE, 2012.

[14] Ayush Shrivastava et al, aˆAIJAutomated Digital Mam-mogram Segmentation Using Dispersed Region Growing and Sliding Window AlgorithmˆaAI, 2017 2nd International Con-ference on Image, Vision and Computing..

[15]Jaya Sharma et al, ˆAIJIdentificationa of Pre-processing Technique for Enhancement of Mammogram ImagesˆAI, 2014 International Conference on Medical Imaging, m-Health and Emerging Communication Systems

[16]NungsanginlaLongkumer, Mukesh Kumar and RohiniSax-ena, Contrast Enhancement Techniques using Histogram Equal-ization: A Survey, International Journal of Current Engineering and Technology, Vol.4, No.3 (June 2014).

[17]NungsanginlaLongkumer`E , e, MukeshKumar`E, e and RohiniSaxena`E, e, ”Contrast Enhancement Techniques using Histogram Equalization: A Survey”, International Journal of Current Engineering and Technology.`

[18]LeilaMalihi, Karim Ansari-Asl, ”Malaria parasite detection in giemsaˆA¸Sstained blood cell images”, 2013 8th Ira-nian Conference on Machine Vision and Image Processing (MVIP).

[19]Yanling Zhang, Wenhao Zhou, Weirong Xu, Li Li, ”Lymph Node Image Segmentation Based on Fuzzy c-Means Clustering and an Improved ChanˆA¸SVese Model”, 2013 6th Inter-national Congress on Image and Signal Processing (CISP 2013).

[20]Herwanto, AniatiMurniArymurthy, ”A system for com-puter aided diagnosis of breast cancer based on mass analy-sis”, 2013 International Conference on Robotics, Biomimet-ics, Intelligent Computational Systems (ROBIONETICS) Yogyakarta, Indonesia, November 25-27,2013.

[21]Agung W. Setiawan, Tati R. Mengko, Oerip S. Santoso, Andriyan B. Suksmono, ”Color retinal image enhancement using clahe”, Biomedical Engineering Research Group SEEI, InstitutTeknologi BandungBandung, Indonesia.

[22]AmitKamra, V K Jain (Member IEEE), ”Enhancement of Subtle Signs in Mammograms Using Multiscale Morpho-logical Approach”, 2013 IEEE Point-of-Care Healthcare Tech-nologies (PHT) Bangalore, India, 16 - 18 January, 2013.

[23]VuThanh An and Nguyen Thanh Hai, ”Enhancement of CT Image Using Image Fusion”, The 2013 International Conference on Advanced Technologies for Communications (ATC’13).

[24]Shelda Mohan, M. Ravishankar, ”Modified Contrast Lim-ited Adaptive Histogram Equalization Based on Local Con-trast Enhancement for Mammogram Images”, 2013.

[25] Etta D.Pisano, Shuquan Zong, Bradley M. Hemminger, Marla DeLuca, R.Eugene Johnston, Keith Muller, M. Pa-tricia Braeuning, and Stephen M.Pizer, ”Contrast Limited Adaptive Histogram equalization Image processing to Im-prove the detection of Simulated Spiculations in Dense Mam-mograms”, Journal of Digital imaging,1998.