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Mammographic Image Enhancement analysis using Fuzzy Logic

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Abstract— Breast cancer figures among the leading causes of cancer related deaths among women. Detection of cancer at the initial stages increases the probability of survival of the patient. For this detection, mammography is done. However most of the cases go unnoticed either due to lower contrast variations or due to noise in mammogram images.The main objective of image enhancement is to improve desired characteristics of an image and make it visually better. This paper proposes a method for quantifying the various enhancement techniques used for cancer detection in mammogram images. The paper proposes the use of fuzzy logic to realize this objective. First the mammogram is enhanced using different enhancement techniques. In next step, the frequency domain comparison of the original image and each of the enhanced image is performed. Using this comparison we obtain the variation in the frequencies of the enhanced image as compared with the original image. Finally these variations are then quantized using the fuzzy sets to provide us the merit of the different techniques, of their degree of enhancement.

Keywords—*mammography, breast cancer, fuzzy logic*

I. INTRODUCTION

Biological studies confirm that breast cancer is the result of an accumulation of a large number of individual genetic mutations that collectively alter elements of the complex internal signaling system of a cell. These aberrant genetic alterations, when assembled in a single breast cell, disrupt the control system to the extent that the cell functions autonomously in an erratic and irregular manner. Continual replication of a corrupted cell results in the formation of a colony of abnormal cells that may accumulate other aberrant mutations to eventually initiate cancer. What causes these mutations has been the topic of debate over a number of years, but because so many genetic alterations are involved, it is now conceded that one single factor could not possibly initiate all the changes. One plausible explanation involves a sequence of random, accidental, spontaneous mutations during normal stem cell replication. Some of these mutations may be an advantage to the host and their creation advances the functional ability of the breast, whereas abnormal mutations are usually deleted after activation of the complex apoptotic and inhibitory signaling system. When the defense system is corrupted, cells carrying the abnormal genes are able to avoid elimination, eventually passing abnormal mutations from one cell generation to the next. Accumulation of genetic abnormalities, over time, leads to development of a colony of cells that are pathologically abnormal. As far the origin of cancer is concerned, its initiation takes place by the formation of tumor.

Fig. 1: Stages of cancer from Normal to Benign and Malignant [1]

The time span for the evolution and growth of the tumor differs between individual.As in other cancers it spreads to other tissues thus causing dissemination cancers.So early detection and treatment can minimize this phenomena and give a better diagnosis for the patient.Early warning signs of breast cancer may involve the discovery of a new lump or a change

in the breast tissue or skin. A clinical check involves a health care professional check for any lumps or physical change in the breast which might be further investigated by mammography.

II. Literature Review

The researches done with CAD tools on mammograms has limited its scope to the enhancement part for detection of cancer cells[1][2][3][4][5][6][7][8][9][10].Fuzzy Logic has also been used for the same[11][12][13].However approach has been made to quantify the enhancement techniques[14].Our paper proposes the use of fuzzy Logic as a tool for efficient quantification of the different enhancement techniques(equalization enhancement,edge sharpening, non-linear enhancement, wavelet enhancement, local statistics enhancement).

III. Problem Statement

Objective and quantitative analysis facilitated by the application of computers to bio medical image analysis leads to a more accurate diagnostic decision by the physician. The interpretation and analysis of medical images represents an important and exciting part of computer vision and pattern recognition. Early detection of breast cancer is required for providing a remarkable reduction in disease mortality.Therefore the proposed work will be focused on the development of the fuzzy controller for quantitative measure of contrast enhancement in mammograms for earliest detection of suspicious mass.

IV. Solution Statement

First the given breast mammogram(the three data sets of the mammogram considered, i.e. Benign, Normal and Malignant) is subjected to different image enhancement techniques (equalization enhancement, edge sharpening, non-linear enhancement, wavelet enhancement,local statistics enhancement). A frequency domain analysis of these enhanced images in comparison with the original image is then performed. The frequency domain analysis results are then used to provide a figure of merit (from 1-5) to the different techniques in accordance with the fuzzy set rules.

V. Solution Methodology

The figure below(fig. 2) shows the methodology used for the quantification of the different enhancement techniques used for breast mammography.

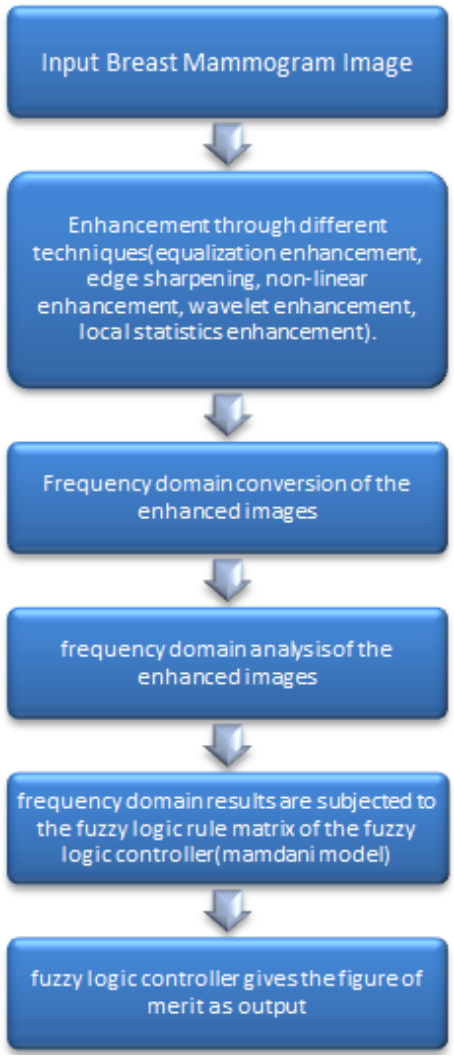

Fig. 2: flowchart for the process followed for quantification of the enhancement techniques using fuzzy logic controller.

Original image i.e. mammograms are enhanced using various techniques to easily recognize the mass formation in the breast, this area is termed as region of interest (ROI).). In this paper,work has been done to develop fuzzy controller for quantitative measurement degree of contrast enhancement,five enhancement techniques are used for the comparison of their performances on any particular image. By analyzing the original and enhanced image in frequency domain, frequency component of both the images is compared. This comparison accordingly defines the amount of enhancement applied on the test image and among all the defined enhancement techniques the fuzzy controller assigns a figure of merit in accordance with the rule. The performance metric in frequency domain that compares frequency response of original and enhanced image to quantitatively evaluate the degree of contrast enhancement provided by an enhancement technique is given for the two frequency band as:

$$LF = \frac{avg(f_{original} - f_{enhanced})}{f_{averag(lower)}}$$

$$HF = \frac{avg(f_{original} - f_{enhanced})}{f_{averag(higher)}}$$

where,

LF is the frequency value of the lower frequency band for an enhancement technique.

HF is the frequency value of the higher frequency band for an enhancement technique.

$f_{original}$ is the frequency response of original mammogram.

$f_{enhanced}$ is the frequency response of enhanced mammogram.

$f_{average}$(lower) is the average frequency response in the lower frequency band.

$f_{average}$(higher) is the average frequency response in the higher frequency band.

The frequencies thus obtained are fed to the mamdani fuzzy controller which then quantifies the obtained results using the membership functions (negative high, negative medium, negative low, positive low, positive medium, positive high).The membership functions are shown below.

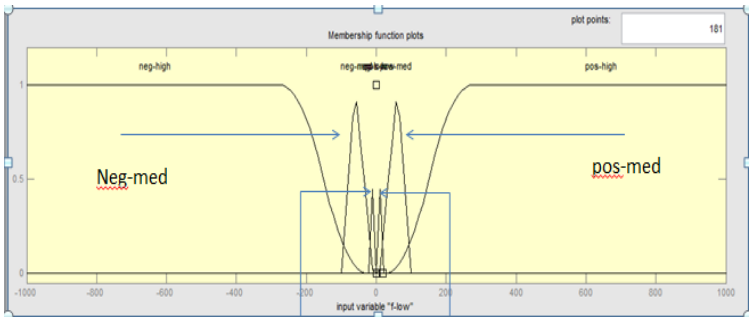

Fig. 3: Membership functions for the input variable(low frequency and high frequency)

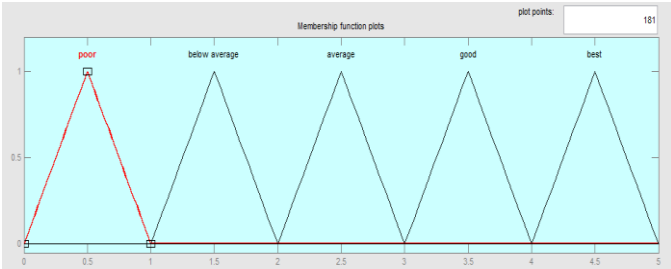

Fig. 4:Membership functions for the Output variable(figure of merit)

VI. Results and Discussion

The proposed algorithm has been tested on images of benign, malignant breast masses and normal breasts. MATLAB, R2013a platform was used for simulation purpose. By following the test methodology given in this paper, it is observed that slight variation in the frequency of the image gives good results however very large variation in the frequency components degrades the image, as has been concluded in [14]. The above mentioned results are then subjected to the fuzzy controller which provides us with the merit of the techniques. This figure of merit corroborates the results of [14].

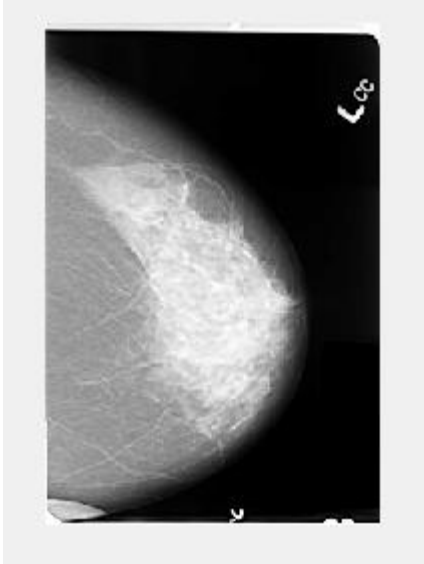

Fig. 5: Input image of breast mammogram (malignant cancer).

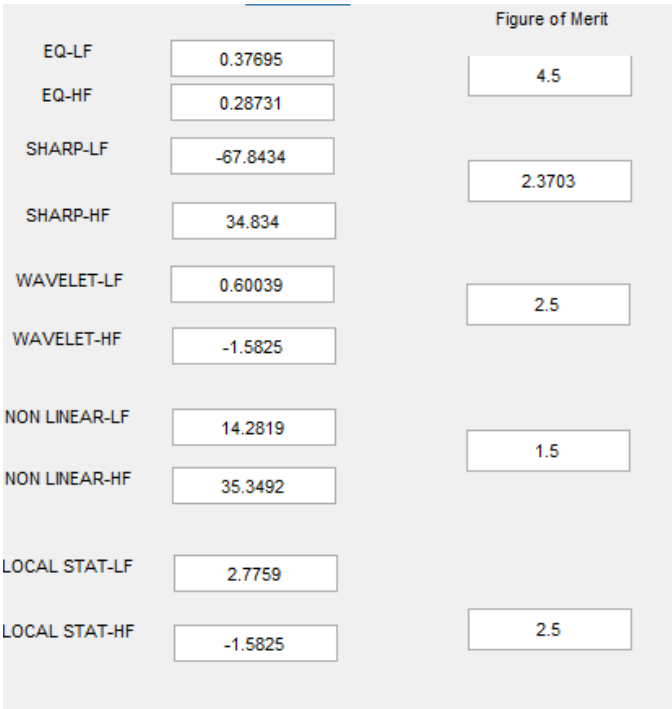

Fig. 6: Values of low and high frequencies for different techniques and the corresponding figure of merit.

VII. CONCLUSION

Digital mammograms are among the most difficult medical images to read, because of the differences in the types of tissues and their low contrasts. Moreover, important visual clues of breast cancer include preliminary signs of masses and micro-calcification clusters. These can be detected in mammograms before a woman or a physician can feel them. So, to choose the enhancement technique that gives the best result for a particular mammogram, among various standard and non-standard enhancement techniques available, all the available technique should be quantitatively measured. Thus, the work in this thesis is therefore focused on development of a figure of merit to quantitatively evaluate the degree of contrast enhancement applied on a mammogram. This also evaluates that which technique is best suited for any particular mammogram. Additionally, it gives information about all those techniques that enhances the image to some extent, if not in

the best possible way and also, those techniques that degrades the quality of the image.

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