MAMMOGRAM MASS SEGMENTATION USING FRACTAL ORIENTED GAMMA TRANSFORMATION

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ABSTRACT

Digital mammogram has become the reliable and most effective screening method for the early detection of breast cancer. A novel Fractal Hurst-based Gamma Transformation (FHGT) is presented in this paper for the segmentation of masses from mammograms. This method is a composition of two mechanisms namely detection of masses from digital mammograms and the segmentation of those detected masses. The artifacts removal and spatial enhancement are performed for pre-processing of the mammograms, which subsequently help in mass detection. The process of segmentation is performed using morphological operations. The proposed FHGT is proved to produce promising results in terms of segmentation that confirms its merit.

KEYWORDS

Digital Mammogram; Gamma Transformation; Fractal Dimension; Fractal Hurst; Masses.

1.INTRODUCTION

Medical Image Processing plays a vital role in the diagnosis of medical images. Image Segmentation subdivides an image into its constituent regions or objects, which offers a platform to retain the essential vital objects/regions of interest and disregard the insignificant details of an image [1,2]. The increased applications of image segmentation in medical imaging, assures the scope for the proposed method in health diagnosis.

Breast cancer is identified as one of the critical causes attributing to women mortality, in both developed and developing countries. The early detection of breast cancer provides enormous scope in containing the death toll. In India, a death rate of one in eight women has been reported due to breast cancer [3-5]. Recently, mammography has become known and effectual means for the early detection of breast cancer and other abnormalities in the breast tissues. A patient is confirmed to have breast cancer if certain types of masses or calcifications which appear as small white specks are recognized in the mammogram [6-8]. As the breast tissues are found to possess self-similar property of fractal objects, fractal-based methods find their place in mammogram segmentation and in the proposed technique it is used for the segmentation of masses from digital mammograms [9-11].

Fractals are of rough geometric shapes which when subdivided into discrete parts, each possesses reduced similarities of the whole object. Fractal dimension is an imperative characteristic of fractal objects, which is an important parameter that measures the fractal property of an object [12-15]. Fractal dimension has got wider applications in the fields of image segmentation and shape recognition.

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In this paper, section 2 describes the basics of the techniques being used in the proposed method, (FHGT) and the computational methodology of mass segmentation. Results and discussion are presented in section 3 while the conclusions are drawn in section 4.

2.FRACTAL GAMMA TRANSFORMATION

2.1.Fractal Dimension

Self-similarity is defined as a property, where a subset is indistinguishable from the whole, when magnified to the size of the whole. Fractals are of rough geometric self similar and irregular shapes which can be subdivided in parts, each of which is reduced to similar of the whole [16-19].

Fractal objects are characterized by their Fractal dimension which is an important characteristic of fractals as it has got information about their geometric structure. In Euclidean n-space, the bounded set X is said to be self-similar when X is the union of N_r distinct non-overlapping components of itself, each of which is similar to X scaled down by a ratio r. Fractal Dimension F_D of X can be derived from the relation [12, 20-22], as

$$F_D = \frac{\log(N_r)}{\log\left(\frac{1}{r}\right)} \tag{1}$$

2.2.Fractal Hurst

The measure of long-memory dependence, Fractal Hurst, is calculated by finding the difference between the topological dimension of the image and its fractal dimension. Considering the topological dimension T_D and fractal dimension F_D of the image, the Fractal Hurst F_H value can be calculated as

$$F_H = T_D - F_D \tag{2}$$

2.3.Computational Methodology

For an input mammogram image I, initially the fractal dimension, F_D is computed by differential box counting method, using Eqn.(1). Then, F_H is calculated by finding the difference between F_D and T_D of the image. The mean M and standard deviation SD are also computed for the image. Subsequently, the Fractal Threshold T is computed using SD and F_H. A set of properties for each labelled region in the label matrix LM is measured using the actual number of pixels in the region and those properties in combination with the morphological operations would remove all the labels/artifacts present in the input image, to acquire the artifacts removed image IA.

The artifact removed image IA is further enhanced spatially to acquire IE using 2D convolution that computes the two-dimensional convolution of the artifacts removed image IA by having the convolution mask as [-1 -1 -1; -1 8 -1; -1 -1 -1]. The statistical mean M of the image is calculated and the maximum and minimum intensity of the image are taken as the Gamma values γ1 and γ2 of the enhanced image. Using those gamma values and the fractal hurst, the modified gamma transformation is done using

$$IE_1 = IE\hat{}(F_H);$$

$$IE_2 = IE\hat{}(F_H^2);$$

$IE_3 = IE\text{^}(F_H{}^3)$; and

$IE_1 = [IE_1 - \gamma 2(IE_1)] / [\gamma 1(IE_{1)} - \gamma 2(IE_1)]$;

$IE_2 = [IE_2 - \gamma 2(IE_2)] / [\gamma 1(IE_{2)} - \gamma 2(IE_2)]$;

$IE_3 = [IE_3 - \gamma 2(IE_3)] / [\gamma 1(IE_{3)} - \gamma 2(IE_3)]$;

$$IG = IE_1+IE_2+IE_3 \quad (3)$$

where IE is the initial enhancement image and IE_1,IE_2 and IE_3 are intermediate spatially enhanced images of IE using F_H. IG is the modified gamma transformed image which is obtained as the summation of those intermediate enhanced images IE_1, IE_2 and IE_3

Further, the Fractal Gamma Transformation is carried out by the application of the linear transformation as follows:

if $(IG(i, j)< F_H)$

$$IFG(i, j) = M *(1-(IG(i,j)*IA(i,j))); \quad (4)$$

Subtraction of the image IFG from IE yields the segmented image IS. Finally, applying the morphological reconstruction operation again on the segmented image IS will result in the image IM that produces the final segmented mass from the input mammogram image.

The algorithm of the proposed method is given herein under:.

Algorithm : Segmentation of mass from mammogram

**Aim : ** To segment the mass from mammogram

**Input : ** A 2-Dimensional mammogram image, I

Output : Segmented mass from mammogram

1: Read a 2-D input mammogram image I

2: Cover the image with boxes of size r.

3: Let minimum and maximum gray levels of I present in *k* and *l* boxes respectively.

4: Calculate $n_r(i, j) = l - k + 1$

5: Find $Nr = \sum n_r(i, j)$

6: Compute Fractal Dimension F_D using Eqn.(1).

7: Calculate Standard Deviation SD for I.

8: Calculate Fractal Hurst F_H using Eqn.(2).

9: Formulate Fractal Threshold T, using F_H and SD.

10: Remove the artifacts by region property to acquire, IA.

11: Enhance the artifacts removed image IA to IE using 2D convolution.

12: Apply $\gamma 1$and $\gamma 2$with Fractal Hurst using Eqn.(3) to acquire IG.

13: Apply Fractal Gamma Transformation using Eqn.(4) to acquire IFG.

14: Subtract the image IFG from IE to acquire the mass detection image IS.

15: Dilate, Erode and reconstruct the image IS to achieve final segmented mass IM.

16: Stop

3.RESULTS AND DISCUSSION

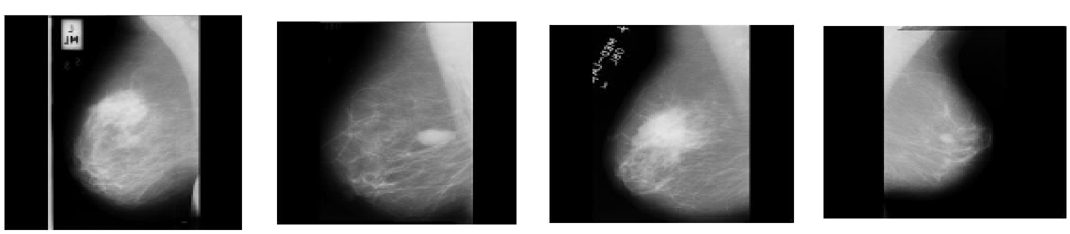
The proposed technique is coded using Matlab 7.8. Different mammogram images with different types of masses were collected and tested from the Mini-Mammographic Database of the Mammographic Image Analysis Society from the Pilot European Image Processing Archive (PEIPA) at (ftp://peipa.essex.ac.uk/ipa/pix/mias/) the University of Essex.

As per the principle of the proposed methodology, the input image is processed to remove the label like artifacts in it and subsequently gets enhanced by 2D convolution. For illustrative purpose, the results of 4 mammograms (mdb111.pgm, mdb025.pgm, mdb081.pgm (left view)) and mdb010.pgm (right view)) are depicted in Figure.1 (a)-(g). The original image, artifacts removed image and spatially enhanced image for the input mammograms are depicted in Fig.1 (a)-(c) respectively.

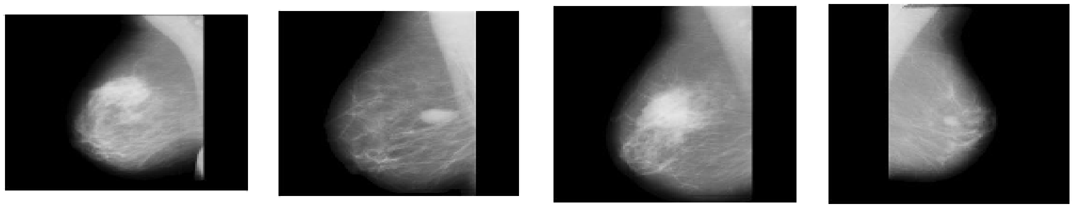
The Fractal Gamma Transformation is applied with the linear transformation which is depicted in Fig.1(d) and the mass is detected by subtracting the transformed image from the enhanced image, which is being shown in Fig.1(e). Then, the morphological operations are applied to achieve reconstructed image that is shown in Fig.1(f) and subtracting the reconstructed image from the mass detected image gives the final mass segmentation which is depicted in Figure.1(g).

Those aforementioned resultant images for 4 mammograms (mdb111.pgm, mdb025.pgm, mdb081.pgm (left view)) and mdb010.pgm (right view)) are depicted in Fig.1(a1)-(a4) through Fig.1(g1)-(g4). The mass segmentation results clearly shows that this presented technique using FHGT is proved to be precise and robust in the segmentation of masses from a digital mammogram.

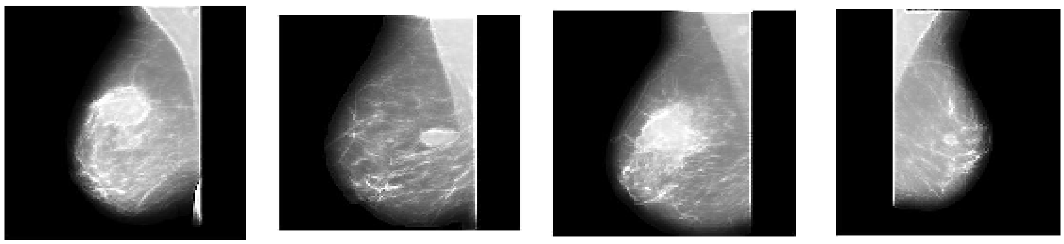
Mdb111 **Mdb025** **Mdb081** **Mdb010**



(a1) (a2) (a3) (a4)

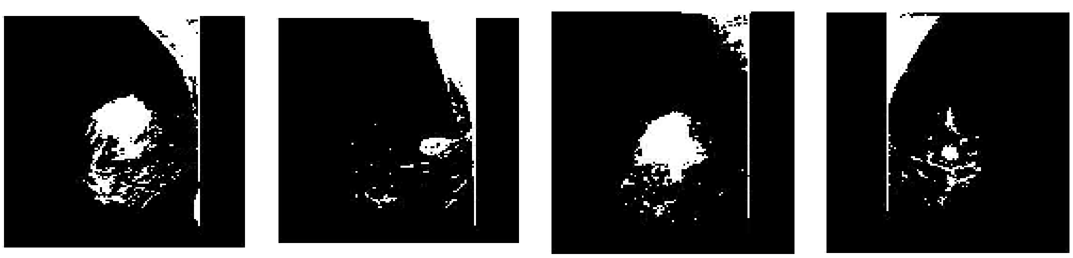


(b1) (b2) (b3) (b4)



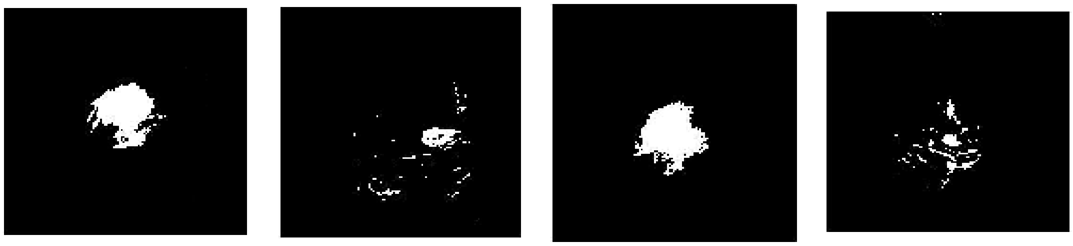
(c1) (c2) (c3) (c4)

(d1) (d2) (d3) (d4)



(e1) (e2) (e3) (e4)

(f1) (f2) (f3) (f4)



(g1) (g2) (g3) (g4)

Figure.1: Input, Intermediate Results and Output of FHGT Segmentation

(a1) - (a4) Original Image

(b1) - (b4) Artifacts Removed Image

(c1) - (c4) Spatially Enhanced Image

(d1) - (d4) Fractal Gamma Transformation

(e1) - (e4) Detected Image

(f1) - (f4) Reconstructed Image

(g1)-(g4) Final Segmented Mass

4.CONCLUSION

This paper presents a novel fractal bound gamma transformation for the detection and segmentation of masses in digital mammograms to enable an early diagnosis. The proposed technique, FHGT endorses the potential of fractal dimension that helps in precise mass segmentation more precisely and can be used for developing an interactive expert system for an early detection of breast cancer. Further, the results obtained over various mammograms from mini-MIAS database have substantiated the merit of this method. In the future scope of the study, after detecting and confirming the masses, the classification on masses can be done as whether benign or malignant.

REFERENCES

[1] Rafael C. Gonzalez, Richard E. Woods, (2009) Digital Image Processing, Second edition, Prentice Hall.

[2] Milan Sonka, Vaclav Hlavac, Roger Boyle, (2008) Digital Image Processing and Computer Vision, Cengage Learning.

[3] Guillaume Kom, Alain Tiedeu, Martin Kom, (2012) "Automated detection of masses in mammogram by local adaptive thresholding", Computers in Biology and Medicine 37, pp. 37-48.

[4] Indra Kanta Maitra, et al., (2012) "Technique for preprocessing of digital mammogram", Computer methods and programs in biomedicine 107, pp. 175-188,

[5] Tomislav Stojic, et al, (2006) "Adaptation of multifractal analysis to segmentation of microcalcifications in digital mammograms", Physica A 367, pp. 494-508.

[6] H.D.Cheng, Xiaopeng Cai, Siaowei Chen, Liming Hu, Xueling Lou, (2003). "Computer-aided detection and classification of microcalcifications in mammograms: a survey", Pattern Recognition, Vol. 36, pp. 2967- 2991.
[7] Richard Vuduc, (1997) "Image Segmentation using Fractal Dimension", Report on GEOL 634, Cornell University.
[8] P.Shanmugavadivu, V.Sivakumar, (2012) "Fractal Approach in Digital Mammograms: A Survey", NCSIP-2012, pp. 141-143, ISBN: 93-81361-90-8.
[9] P.Shanmugavadivu, V.Sivakumar, (2012) "Fractal Dimension based Texture Analysis of Digital Images", ICMOC-2012, Procedia Engineering (Elsevier-Scidirect), Vol. 38, pp. 2981 – 2986, ISSN: 1877-7058.
[10] Claudio Marrocco, Mario Molinara, Ciro D'Elia, Francesco Tortorella, (2010) "A Computer-aided detection system for clustered Microcalcifications", Artificial Intelligence in Medicine, Vol. 50, pp. 23-32.
[11] Wael A. Mohamed, Mohamed A. Alolfe, Yasser M. Kadah, (2009) "Fast Fractal Modeling of Mammograms for Microcalcifications Detection", 26th National Radio Science Conference, Egypt.
[12] Paul S Addison, (2005) Fractals and Chaos, IOP Publishing.
[13] Stephen Welstead, (1999) "Fractal and Wavelet Image Compression Techniques", Tutorial texts in optical engineering, Vol.TT40.
[14] P.Shanmugavadivu, V.Sivakumar, (2012) "Fractal Based Detection of Microcalcification Clusters in Digital Mammograms", Proceedings of ICECIT-2012,Elesevier India-ISBN: 978-81-312-3411-2, pp. 58-63.
[15] P.Shanmugavadivu, V.Sivakumar, (2012) "Comparative Analysis of Microcalcifications detected in mammogram images by edge detection using Fractal Hurst co-efficient and Fudge factor", INCOSET-2012, IEEE Xplore, ISBN: 978-1-4673-5141-6, pp. 174-179.
[16] P.Shanmugavadivu, V.Sivakumar, (2013) "Segmentation of pectoral muscle in mammograms using Fractal method", ICCCI-2013, IEEE Xplore, ISBN: 978-1-4673-2906-4, pp. 1-6.
[17] P.Shanmugavadivu, V.Sivakumar, (2015) "Segmentation of Masses in Digital Mammograms using Fractal-Bound Computing Technique for Breast Cancer Prognosis", International Journal of Applied Engineering Research, Vol.10, No.31, pp.23187-23192.
[18] P.Shanmugavadivu, V.Sivakumar, (2014) "Wavelet Transformation-Based Detection of Masses in Digital Mammograms", International Journal of Research in Engineering and Technology, Vol.03 (02), pp.131-138.
[19] P.Shanmugavadivu, V.Sivakumar, (2014) "A Novel Technique for Mammogram Mass Segmentation Using Fractal Adaptive Thresholding", Lecture Notes in Electrical Engineering, Chapter 25, Vol.291, pp.213-220, Springer.
[20] P.Shanmugavadivu, V.Sivakumar, (2014) "Intensity-Based Detection of Microcalcification Clusters in Digital Mammograms using Fractal Dimension", Advances in Intelligent Systems and Computing, Vol.236, pp.1293-1299, Springer.
[21] P. Shanmugavadivu, V. Sivakumar, Rashmi Sudhir, (2016), "Fractal Dimension-Bound Spatio-Temporal Analysis of Digital Mammograms", Eur. Phys. J. Special Topics © EDP Sciences, Springer-Verlag, DOI: 10.1140/epjst/e2016-02613-0, Springer.
[22] R. Lopes, N. Betrouni, (2009) "Fractal and Multifractal analysis: A review", Medical Image Analysis 13, pp. 634-649.

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