

On Using Lacunarity for Diagnosis of Breast Diseases Considering Thermal Images

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Abstract— A experimental scheme for identification of breast diseases based on thermal images is presented. A set of infrared images from a database that is being developed were used for an experimental investigation considering the image Lacunarity measures by the gliding box algorithm. This approach generates a parameter to distinguish from normal to abnormal breast diagnostics. We propose two interpretations based in similarity of the breast anatomic aspects. The original contributions of this work are the use of thermal image on diagnosis of breast disease and an approach that classifies images based on lacunarity indexes.

Keywords—component; Biomedical Image Processing, thermo-mammography, lacunarity, fractal parameters

I. INTRODUCTION

The thermal inspection is a non invasive diagnostic tool that makes use of infrared radiation of the body. In this work, the images captured by infrared cameras are used to generate thermo-mammography. Such technique do not require ionizant radiation, breast compression or intravenous contrast injection as the other types of exams. A useful feature of thermal biomedical information is that it detect abnormalities in very early stage. Due to the importance of large amount of data to extract features to help physicians, a thermic image database is being developed[1]-[2].

It is a experimental fact that an modification in breast temperatures is associated with tissue modification. For instance, tumor cells produce angiogenic substances that will increase metabolic activity and vascular circulation in cancerous tissue and surrounding area. Malignant aspects always change the normal breast temperature [3]. Another aspect of thermal mammography is the precocious detection of any breast problem [4]. Besides, duo to the enhanced clarity of thermo-mammographic images, it is much easier distinguish malignant situations and fibrocystic breast or women who are in hormone replacement.

In this paper, we consider that breast lesions will produce a variation of thermic distribution in the acquired image. Nevertheless, such variation will not be in the same shape in both breast. This will result on differences in the texture of the surface of the acquired image. For a texture analysis we propose to use the image fractal properties.

Commonly, fractal concepts are used in analysis of complex natural patterns like landscapes, blood vessels or

remote sensing [5]-[6]-[7]. Three fractal parameters have been described: fractal dimension, succolarity and lacunarity [7]. The fractal dimension quantifies the density of fractals (or any images) on its metric space. The fractal dimensions are then an objective way to compare one fractal (or figure) to another. The succolarity measures the “percolation” degree of an image (how much a given “fluid” can flow through this image). The lacunarity values reflects the degree or aspect of gap distribution over the entire image. This permits detection of the presence of hierarchical structures or segmentation considering the homogeneity in gaps distribution, random or self-similar behavior. Images with large gaps or holes present higher lacunarity and an image with high homogeneous structure presents lower lacunarity [8]-[9]. This propriety and the nature of lacunarity features evaluation is the paper central focus. The goal of this work is to study the possibility of using Fractal Geometry Lacunarity to measures some abnormality in thermo-mammographies.

II. PROPOSED APPROACH

The first step of our approach consists of extracting the region of interest (ROI) of each thermo-mammography which corresponds to left and right breast regions using a window of the same size for each breast. The Figures 1 and 4 exhibit typical thermo-mammography of a malign and normal case, respectively. The region of interest of these figures are presented in Figure 2 (abnormal case) and Figure 5 (normal case) that were used to compute the lacunarity values performed by the gliding box algorithm [8] implemented as presented in [10] and [11]. Fig. 3 presents one output log of lacunarity versus size of gliding box log for each breast of the patient on Figure 2. Figure 6 shows the graphic for each breast of the patient on figure 5. These plots, including the linear fit, will be considered here to characterize normal or anomalous breast.

The first observation is the behaviors of each curve. If they are similar but only translated like the graphs in Figure 6 the breast are considered as having almost the same thermal distribution meaning normal breast. Figures 3 and 6 produce experimental measurements of lacunarity performed for each breast using boxes of increasing size. Here we call this graphics as *lacunarity profile*. As the box sizes change, the approximate $\ln(\lambda)$ values are plotted in doubly logarithmic scale. They fall

on curves of negative slopes but this slope had no theoretical interpretation. The present approach, on the other hand

some kind of tendency to intercept it means divergence slope and so much different thermic distribution. However, patient with some kind of disease like presented in Figure 1 result on graphs (Figure 3) without similarity. Figure 7 presents together the four curves commented (two plots for each patient) for better visualization of this behavior on characterization of normal and abnormal tissues.

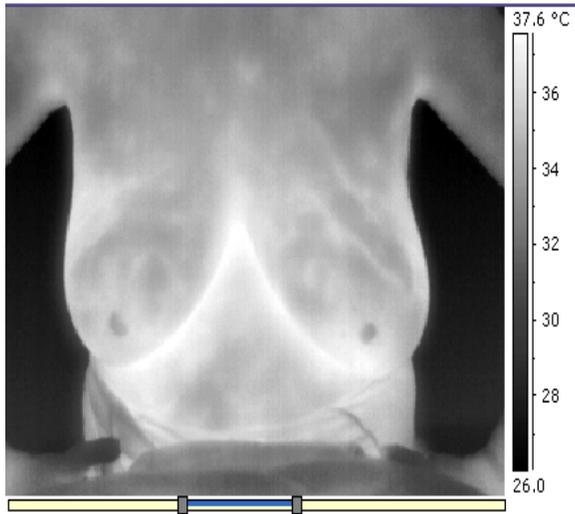


Figure 1- Thermal image of a patient with malign tumor

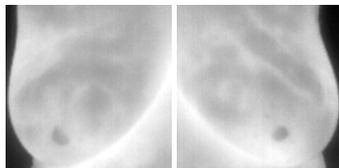


Figure 2 – Segmented right and left breast from figure 1

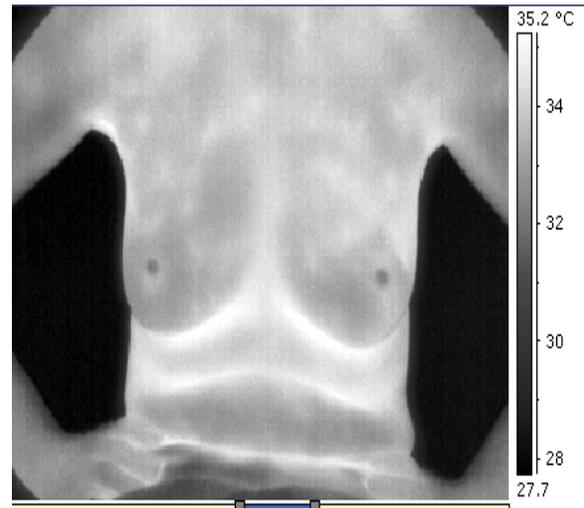


Figure 4 - Thermal image of a patient with normal breast

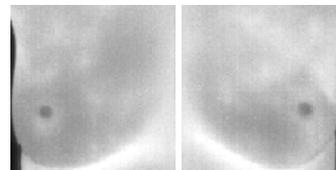
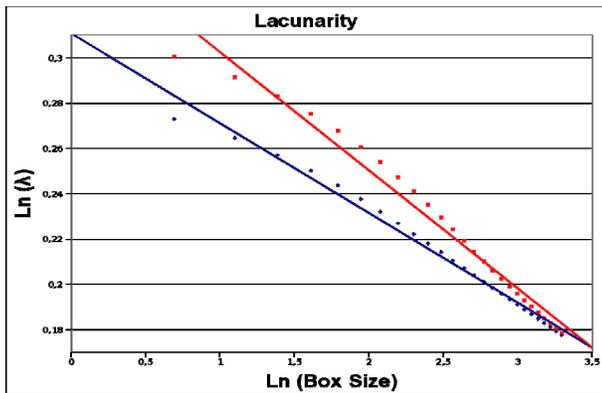
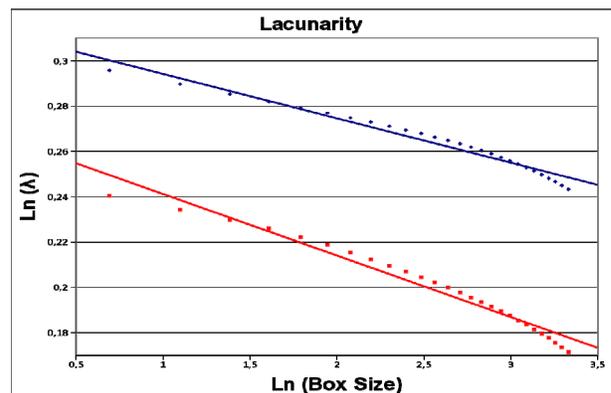


Figure 5- Segmented right and left breast from figure 4



- ♦ right breast not normal
- left breast not normal

Figure 3 – Lacunarity values of images in figure 2 in log x log curves



- ♦ right breast normal
- left breast normal

Figure 6- Lacunarity values of images in figure 5 in log x log curves.

interprets similar slope as a measure of breast thermic similarity. Therefore, almost parallel curves means almost similar thermic surface distribution on both breast. When the curves present

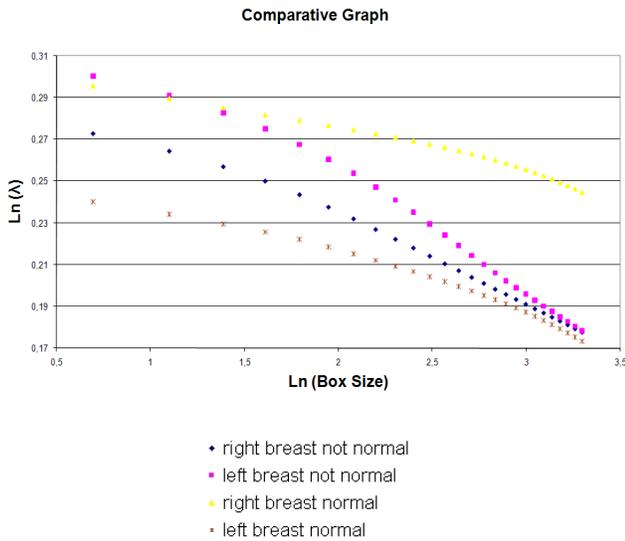


Figure 7- Comparative analysis of both patient

III. NUMERICAL EXPERIMENTATION

For a general analysis the data present in graphs like Figure 3 and 6 are used for linear approximation using the minimum square fit method. Table 1 presents the angular coefficient of linear adjust of lacunarity profile for each breast for six thermo-mammographies extracted from the medical database presented in [12]. The difference between the angular coefficients is small generating numbers form 10^{-2} to 10^{-4} . For more easier difference evaluation, we define a parameter F as

$$F = |\ln(\text{right breast coefficient} - \text{left breast coefficient})|.$$

Big values of F represents small difference between breast lacunarity profile angular coefficient. This parameter is also shown in Table 1. These results show that small F (large differences) are indication of some kind of abnormality. Based on data presented in Table 1 we suggest adopting $F < 6$ as reference of abnormality. A schematic explanation of this approach can be seen step by step on Figure 8.

We propose an interpretation of numerical results. Normal breasts has little tissue differences. However, in pathogenic situation is more common bigger differences and irregular tissue patern. The parameter F used for our analysis is evaluated as the difference of the coefficients of the linear fit to the lacunarity profile of each breast. The regular evolution of lacunarity with gliding box size suggest a more regular breast structure. Therefore, the parameter comparison is a reference of the breasts state and bigger differences present a possibility of abnormal case but not a necessarily a malignant.

For a test we extract information, using the same approach, of more nine thermo-mammographic images presented in Table 2. A simple examination show that the criteria $F < 6$ is representative for all abnormal cases but it can wrongly classify as abnormal exams of a patients that do not have pathological problems. It is important to observe that the thermic image database contains exams that shows some type of problem and that the medical diagnosis is presented in the tables.

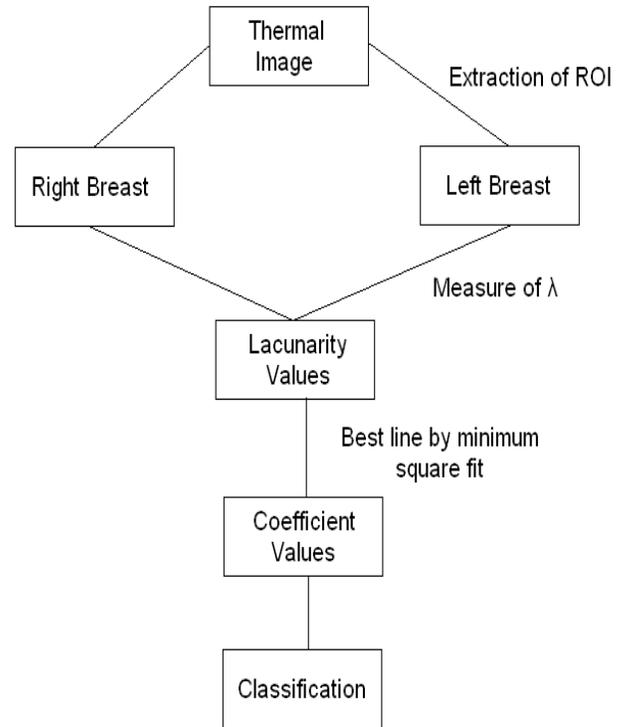


Figure 8- The steps used on this analysis

TABLE 1 – Analysis of a thermo-mammography set

Image number	Breast Coefficient (10^{-2})		F = $ \ln$ $ \text{Difference} $	Diagnosis
	Right	Left		
3417	-2.9769	-3.3070	5.71	Abnormal
2889	-2.3807	-2.9661	5.14	Abnormal
3740	-3.9626	-5.2180	4.38	Abnormal
5077	-3.2413	-3.2029	7.87	Normal
5528	-4.0711	-4.1281	7.47	Normal
3631	-1.9111	-1.9830	7.23	Normal

TABLE 2 – Parameter test

Image number	Breast Coefficient (10^{-2})		F = $ \ln$ Difference	Diagnosis
	Right	Left		
3434	-4.4860	-3.6464	4.78	Abnormal
3924	-4.6471	-5.6650	4.59	Abnormal
5462	-7.7269	-7.3249	4.02	Normal
5855	-1.9586	-2.7152	4.88	Normal
3835	-7.0314	-9.0372	3.91	Abnormal
5140	-8.8023	-9.8480	4.56	Abnormal
5146	-7.6051	-9.4535	4.66	Abnormal
5304	-10.9425	-2.6563	2.52	Abnormal
5137	-10.8503	-11.9214	4.54	Abnormal

IV. CONCLUSIONS

As could be seen by the results of lacunarity values and its evolution in gliding box algorithm were used with some successes on determining the classification of normality/abnormality using as input thermo-mammographic images. We believe that better results on this type of classification of image exams as normal/anormal to help the diagnosis could be achieved combining these approach with other fractal measures like Hurst coefficient, fractal dimension and succollarity. More thermic images of normal cases are important reference for better explanation about the false positive cases. Moreover, the diagnosis using the parameter F could be evaluated with some Artificial Intelligent technique like neural network.

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