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Classification of abnormalities in mammograms by new asymmetric fractal features

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ABSTRACT

In this paper we use fractal method for detection and diagnosis of abnormalities in mammograms. We have used 168 images that were carefully selected by a radiologist and their abnormalities were also confirmed by biopsy. These images included asymmetric lesions, architectural distortion, normal tissue and mass lesion where in case of mass lesion they included circumscribed benign, ill-defined and spiculated malignant masses. At first, by using wavelet transform and piecewise linear coefficient mapping, image enhancement were done. Secondly detection of lesions was done by fractal method as a ROI. Since in investigation of breast cancer, it is important that fibroglandular tissues in both breasts be symmetric and for each asymmetric density, evaluation for malignancy is necessary, we define new fractal features based on extracting asymmetric information from lesions. The fractal features were evaluated on 5 data sets using SVM classifier which enabled to achieve high accuracy in classification of mammograms and diagnostic results. We have also investigated the performance of image enhancement in classification of each data set which shows different effects of enhancement on different lesion types.

1. Introduction

Breast cancer remains a leading cause of death among women throughout the world. The incidence is increasing globally and the disease remains a significant public health problem. Mammography is invaluable in the detection of anomalies (benign and malignant lesions) in the breast [1] and mammography is the current standard test for cancer screening [2].

A screening mammogram has two views of each breast (X-ray pictures takes from different angles): the craniocaudal (CC) view and the mediolateral oblique (MLO) view [3].

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Mammographic interpretation includes the search for asymmetries. The breast should be compared as symmetric organs and the internal structures are fairly symmetric on a mammogram [1]. So strategies for detecting focal abnormalities on screening mammograms include side-by-side comparison in MLO views and CC views [3]. A focal abnormality is one that is confined to a place in the breast and has characteristics that set it off from the normal background tissues [1]. There are kinds of focal abnormalities revealed with a conventional mammogram.

Mass: A mass is a 'space-occupying' lesion seen on at least two projections or 'viewpoints' (CC, MLO), and most mammographically detected breast masses tend to have curved, convex borders.

Asymmetric density: refers to an 'opacity' (obscured view in part of the breast) which is visible on only one projection (or one 'view or angle' of the X-ray) or with a similar shape on two views, but completely lacking borders and the conspicuity of a true mass.

Architectural distortion: An architectural distortion on a mammogram is basically a disruption of the normal 'random' pattern of curvilinear and fine linear radiopaque structures normally seen on a breast X-ray. There is no visible mass, but the distortion often appears as a 'stellate' shape or with radiating spiculations.

All these mammographic findings can be the result of benign or malignant lesions.

The detection of focal abnormalities on screening mammograms is largely a challenge of perception. One reader's focal abnormality may be another's normal breast tissue [1]. To reduce the number of errors in screening mammography, computer-aided detection and diagnosis (CAD) methods have been developed. The idea behind these CAD systems is that when a radiologist carefully inspects mammographic areas that are prompted with CAD, the risk of overlooking a substantial abnormality is minimized. Computer-aided methods for detecting and diagnosis breast cancer have been investigated using many different techniques as well as wavelet methods in image enhancement. Dippel et al. [4] represented that enhancement based on the fast wavelet transform (FWT) suffers from one serious drawback – the introduction of visible artifacts when large structures are enhanced strongly. They compared FWT with Laplacian Pyramid and found the Laplacian Pyramid allows a smooth enhancement of large structures, such that visible artifacts can be avoided. Salmeri et al. [5] presented an algorithm for image denoising and enhancement based on dyadic wavelet processing. They proposed an adaptive tuning of enhancement degree at different wavelet scales, whereas in the case of mass detection, they developed a new segmentation method combining dyadic wavelet information with mathematical morphology. Lang et al. [6] used an undecimated, shift-invariant, nonorthogonal wavelet transform instead of the usual orthogonal one for noise reduction in image enhancement. Emmanouil et al. [7] investigated the effectiveness of a wavelet-based breast-image enhancement filter and conducted comparative evaluation with five histogram equalization mapping functions.

Another technique that was used in CAD system with the aim of improving the accuracy and efficiency of screening programs for detection and diagnosis of breast cancer is fractal. Fractal approach is based on identification of geometric structures that exhibit self-similarity at different scales. The concept of fractal was found to be suitable to explain naturally occurring shapes either complex or simple, such as geometry of leaves, trees, mountains, clouds, and the cratered face of the moon as well as biological structures such as cancer tumors [8]. Li et al. [9] evaluated fractal-based computerized image analyses of mammographic parenchymal patterns in the task of differentiating between women at high risk and women at low risk for developing breast cancer. Chena et al. [10] described fractal characteristics to differentiate the benign from malignant lesions focusing on the study of texture features. Tourassi et al. [11] calculated the fractal dimension (FD) of mammographic region of interest (ROI) using the circular average power spectrum technique: they observed that the presence of architectural distortion disrupts self-similarity properties, and thereby alters the FD of breast parenchyma. Guo et al. [12] presented a detailed study of fractal based methods for texture characterization of mammographic mass lesions and architectural distortion. Rangayyan et al. [13] demonstrated the application of fractal analysis and texture measures for the detection of architectural distortion in screening mammograms taken prior to the detection of breast cancer. Tao et al. [14] presented an approach to feature extraction with wavelet and fractal methods in pattern recognition. They used fractal transformation to develop a high-speed feature extraction technique.

Outline of the paper is as follows. In Section 2, materials and methods are presented. In this section a description of image enhancement and detection method are provided which follow by definition of new fractal features for extracting information of lesions. In Section 3, performance results for detection of masses as well as the classification results are presented. Concluding remarks are given in Section 4.

2. Materials and methods

In this paper we have used a novel asymmetric fractal method to discriminate abnormal tissues from normal ones on the basis of detection and characterization of lesions in mammogram. The method utilizes objective as compared with subjective approaches which are used by radiologists. At first, we enhanced the mammogram images using wavelet transform and piecewise linear coefficient mapping in wavelet domain. Secondly, we calculated the necessary threshold level discriminating lesion from the background tissues by application of fractal method in which lesions are identified as ROI. In continue we defined new fractal features in order to extract efficient features belonging to asymmetric information of lesions in left and right mammograms. They are used for classification mammograms to normal and abnormal ones. We have done classification by SVM method that shows good classification results by using image enhancement. The overall block diagram of this study is expressed in Fig. 1.