Chapter 6
The Role of Self-Similarity for Computer Aided Detection Based on Mammogram Analysis

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ABSTRACT

The improvement on Computer Aided Detection (CAD) systems has reached the point where it is offered extremely valuable information to the clinician, for the detection and classification of abnormalities at the earliest possible stage. This chapter covers the rapidly growing development of self-similarity models that can be applied to problems of fundamental significance, like the Breast Cancer detection through Digital Mammography. The main premise of this work was related to the fact that human tissue is characterized by a high degree of self-similarity, and that property has been found in medical images of breasts, through a qualitative appreciation of the existing self-similarity nature, by analyzing their fluctuations at different resolutions. There is no need to image pattern comparison in order to recognize the presence of cancer features. One just has to compare the self-similarity factor of the detected features that can be a new attribute for classification. In this chapter, the mostly used methods for self-similarity analysis and image segmentation are presented and explained. The self-similarity measure can be an excellent aid to evaluate cancer features, giving an indication to the radiologist diagnosis.

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INTRODUCTION

This chapter is mainly directed for professionals and students working in the area of medical applications and bioinformatics. The chapter covers the development of self-similarity models applied to breast cancer detection through digital mammography. The self-similarity formalism can consolidate the development of these CAD systems, helping the detection rate of techniques based on: contrast enhancement; edge detection, image segmentation, registration and subtraction; multiresolution analysis; statistics and neural networks.

The chapter starts with a clinical background of breast cancer and digital mammography. Afterwards, a comprehensive review of the mostly known self-similarity models is presented. Finally, the solutions for image segmentation of mammogram images are explained. The chapter ends with final remarks about the development of CAD systems based on self-similarity.

BACKGROUND

Breast cancer is one of the major causes for the increase of the mortality among women, especially in developed and under developed countries, and it can be curable if detected at early stages and given proper treatment. Mammography is currently the most effective screening technique capable of detecting the disease in an early stage. Together with breast physical examination, it has been shown to reduce breast cancer mortality by 18-30%. However, statistics show that 60-80% of biopsies, previously recommend for examination of the lesions, are performed on benign cases and approximately 25% of cancers are missed. Such numbers deserve our attention to the additional requirements of the diagnose process. Doctors are expected to find the least stressful and painful way to check the status of the disease. Regarding the unpleasantness of both mammogram and core biopsy exams, reducing the number of false positives becomes as equally important as reducing the number of false negatives.

The anatomy of the breast is the inevitable source of the highly textured structure of the mammograms. Due to its complexity, it provides a difficult input to analyze for radiologists, who are expected to distinguish very subtle abnormalities out of this mass of structural ambiguity. In addition, these abnormalities pointing for the disease are often immersed on a low contrast mammogram background, where the contrast between malignant and normal tissue may be present but below the threshold of human perception.

Mammographic early signs of breast cancer usually appear in the form of clusters of microcalcifications, in isolation or together with other readings, areas of high density breast tissue, called masses. The term mass arises from the characteristic well-defined mammographic appearance, and they tend to be brighter than their surroundings due to the high density within their boundaries.

In order to be able to characterize microcalcifications, radiologists generally rely on their shape and arrangement. Malignant calcifications are typically very numerous, clustered, small, dot-like or elongated, variable in size, shape and density. Benign calcifications are generally larger, more rounded, smaller in number, more diffusely distributed, and more homogeneous in size and shape. However, because of the small size of microcalcifications, the comparison and characterization of benign and malignant lesions represents a very complex problem even for an experienced radiologist (Salfity et al., 2001).

The nature of the two-dimensional mammography makes it very difficult to distinguish a cancer from overlying breast tissues. The mammographic features are generally hard to found because of their superimposition on the breast parenchymal textures and noise. Moreover, breast density is known to be the most affecting factor for mammographic accuracy (Pisano, et al., 2008).