Chapter 14
Classification of Breast Masses in Mammograms Using Radial Basis Functions and Simulated Annealing

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ABSTRACT
We present pattern classification methods based upon nonlinear and combinational optimization techniques, specifically, radial basis functions (RBF) and simulated annealing (SA), to classify masses in mammograms as malignant or benign. Combinational optimization is used to pre-estimate RBF parameters, namely, the centers and spread matrix. The classifier was trained and tested, using the leave-one-out procedure, with shape, texture, and edge-sharpness measures extracted from 57 regions of interest (20 related to malignant tumors and 37 related to benign masses) manually delineated on mammograms by a radiologist. The classifier’s performance, with pre-estimation of the parameters, was evaluated in terms of the area $A_z$ under the receiver operating characteristics curve. Values up to $A_z = 0.9997$ were obtained with RBF-SA with pre-estimation of the centers and spread matrix, which are better than the results obtained with pre-estimation of only the RBF centers, which were up to 0.9470. Overall, the results with the RBF-SA method were better than those provided by standard multilayer perceptron neural networks.

DOI: 10.4018/978-1-60960-553-7.ch014
INTRODUCTION

Breast Cancer

Mammography is the most efficient method for early diagnosis of breast cancer. In Canada and the United States, mammography is used for early detection of breast cancer in asymptomatic women between the ages of 50 and 69 years, or women under the age of 40 years with high risk of breast cancer. In clinical diagnostic procedures, decisions are made based upon multiple mammographic features, which are used to classify a case as normal or abnormal. By studying the masses present in a mammogram, a radiologist can decide whether benign breast disease or cancer is present or not, and in the case of a positive finding, request a biopsy for a final diagnosis. However, studies have shown that the positive predictive value (PPV, given as the ratio of the number of breast cancers found to the total number of biopsies performed) of such procedures is only 15% to 30% (Kupinski, & Anastasio, 2009). Considering the traumatic nature and cost of biopsy, it is important to increase the PPV without reducing the sensitivity of mammography in breast cancer detection.

Several studies have shown the potential of computer-aided diagnosis (CAD) procedures in increasing the diagnostic accuracy by reducing the false-negative rate while increasing the PPV of diagnostic procedures based upon mammographic abnormalities (Rangayyan, Mudigonda, & Desautels, 2000; Hadjiiski, Sahiner, Chan, Petrick, & Helvie, 1999; Alto, Rangayyan, & Desautels, 2005; André, & Rangayyan, 2006; Mudigonda, Rangayyan, & Desautels, 2000; Mudigonda, Rangayyan, & Desautels, 2001; Sahiner, Chan, Petrick, Helvie, & Goodsitt, 1998; Sahiner, et al. 2001). The aim of the present work is to investigate the problem of classifying mammographic masses with high accuracy, using measures of shape complexity, edge-sharpness, and texture (Rangayyan, et al. 2000; Hadjiiski, et al. 1999; Alto, et al. 2005; André, & Rangayyan, 2006; Mudigonda, et al. 2000; Mudigonda, Rangayyan, & Desautels, 2001; Sahiner, Chan, Petrick, Helvie, & Goodsitt, 1998; Sahiner, et al. 2001). We propose a classifier using radial basis functions (RBF) (Haykin, 1999) and simulated annealing (SA) (Haykin, 1999), along with nonlinear and combinational optimization (Haykin, 1999; Broomhead, & Lowe, 1988). The results of the proposed approach are compared with the results obtained by André and Rangayyan (2006) and Alto et al. (2005), who used standard artificial neural networks (ANNs) and linear discriminant analysis (LDA), respectively, with the same dataset and features as in the present study.

Radial Basis Functions for Pattern Classification

The design of a pattern classifier can be viewed as an attempt to solve an optimization problem, known in statistics as stochastic approximation. In this approach, the learning process is the same as finding a surface in a multidimensional space that provides the best adaptation of the data used to train the classifier. On the other hand, the ability of generalization of the classifier is similar to using the multidimensional surface as above to interpolate the data to test the classifier. This motivates the use of RBFs (Haykin, 1999) to design ANNs that can separate classes, that is, perform pattern classification. In the context of ANNs (Haykin, 1999), the hidden layer provides
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