

Chapter 3.14

Neural Networks for the Classification of Benign and Malignant Patterns in Digital Mammograms

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ABSTRACT

This chapter presents neural network-based techniques for the classification of micro-calcification patterns in digital mammograms. Artificial neural network (ANN) applications in digital mammography are mainly focused on feature extraction, feature selection, and classification of micro-calcification patterns into 'benign' and 'malignant'. An extensive review of neural network based techniques in digital mammography is presented. Recent developments such as auto-associators and evolutionary neural networks for feature extraction and selection are presented. Experimental results using ANN techniques on a benchmark database are described and analysed. Finally, a comparison of various neural network-based techniques is presented.

INTRODUCTION

Every year many women die from breast cancer worldwide. A recent study on breast cancer shows that one of every three cancer diagnoses in women is a breast cancer (<http://www.breastcancerfund.org> - Breast Cancer Facts 2003). Reports by various cancer institutes estimate that one in eight women develops breast cancer in the U.S. (http://www.breastcancerfund.org/disease_facts.htm - Breast Cancer Facts 2002), one in nine women in the UK and Canada (<http://www.cancerscreening.nhs.uk/breastscreen/breastcancer.html>), and one in ten women in Australia (<http://www.nbcc.org.au/>). The Australian National Breast Cancer Centre also reports that nearly 3% of women die from breast cancer worldwide, with the risk increasing with age, particularly after 50.

Digital mammography is considered to be one of the most reliable methods for early detection of breast cancer. The introduction of mammography screening in 1963 brought a major revolution to breast cancer detection and diagnosis. It has been widely adopted in many countries, including Australia, as a nationwide public health care program. According to the American College of Radiology, the decline in the number of breast cancer deaths corresponds *directly* to an increase in routine mammography screening (<http://www.acr.org>).

In digital mammography, most breast cancers are detected by the presence of micro-calcifications, which are one of the mammographic hallmarks of early breast cancer; they appear as a small bright spot on the mammogram. To decide whether a suspicious area on a digital mammogram contains a benign or malignant breast abnormality, traditionally the tissue has to be removed for examination using breast biopsy techniques.

Advanced image processing techniques are able to detect breast abnormalities efficiently; though their classification as “malignant” or “benign” still remains a challenging problem (Aghdasi, Ward, & Palcic, 1994; Gonzalez & Woods, 1993; Jain, 1995; Karssemeijer, 1994; Karssemeijer, Thijssen, Hendriks, & van Erning, 1998; Kopans, 1998; Lee & Bottema, 2000; Masek, Attikouzel, & deSilva, 2000; Neiber, Mueller, & Stotzka, 2000; Pereira & Azevedo, 2000; Sonka & Fitzpatrick, 2000; Umbagh, 1998; Wei, Laurence, & Clark, 1994; Yin, Giger, Vyborny, Doi, & Schmidt, 1993; Yoon, Ro, Kim, & Park, 2002; Zheng, Qian, & Clarke, 1994).

The abundance of variety and lack of individuality in micro-calcification patterns make their classification challenging for expert radiologists, even in high-resolution mammograms. Worldwide mass usage of screening mammography generates numerous amounts of mammograms every year,

which requires a large number of skilled radiologists for interpretation. The variety of abnormal structures, long reading time, and monotony of interpretation work often produces human errors, missing either malignant cases or more benign biopsies. Therefore, there is a critical need for an intelligent system which can interpret mammograms accurately and uniformly using expert knowledge based on learning from experience. Along with expert radiologists, a computer-aided intelligent classification technique can be effectively used to improve and speed up the overall interpretation process.

Artificial neural networks (ANNs) have extraordinary generalization capabilities, which make them very suitable for use in computer-aided intelligent systems for breast cancer diagnosis (Bakic & Barzakovic, 1997; Cheng, Cai, Chen, Hu, & Lou, 2003; Wei, Nishikawa, & Doi, 1996; Wu, 1993). ANNs are adaptive intelligent tools that learn from examples (training set) and generalize new cases (test set) which they have never seen before. Recently artificial neural networks have been used in the detection and classification of calcification and mass types of breast abnormalities. Some ANNs, along with other intelligent techniques, produce promising results in distinguishing benign from malignant patterns.

The remainder of this chapter is divided into four sections. The first presents a general overview of research methodology using neural networks. This section presents various benchmark databases, detection algorithms, feature extraction, selection, and classification techniques. The next section presents some recent results using neural evolutionary and auto-associator-based neural classification techniques. A comparative analysis of neural techniques is presented in the following section. The final section concludes the chapter.

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