Breast Density Dependent Computer Aided Detection

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Abstract. This paper describes initial steps towards the development of a Computer Aided Detection (CAD) system based on breast density pattern classes. We present evidence that the sensitivity and specificity of such a system will improve if it is developed for, and applied to, specific breast density classes.

1 Introduction

Mammographic CAD systems are increasingly used clinically to support radiologists in their evaluation of mammograms. Modifications to the UK National Breast Screening Programme, such as requirements for an additional mammogram view, extension of the age range of women invited to screening, combined with the demographic increase resulting from the baby boom generation entering the screening programme are resulting in a huge increase in film reading [2] at a time when it is increasingly difficult to recruit and train skilled mammogram readers. The additional workload necessitates the introduction of alternative strategies for film screening, such as computer-aided detection systems. Possible solutions to this problem include the use of CAD systems to detect and prompt for abnormalities in mammograms, the introduction of pre-screening [4] and the use of image enhancement methods to facilitate viewing, such as the Standard Mammogram Form [6] and texture classification [8].

Pre-screening involves automatic classification into either normal or suspicious categories, followed by viewing of the suspicious cases by the radiologist along with a small sample of the other images for case control [3]. Sensitivity and specificity are two of the figures of merit used to evaluate the performance of such systems. In pre-screening, the overall sensitivity of sorting normal and suspicious categories is limited by the sensitivity of the system. It may be possible, however, to pre-screen a more limited set of films, such as those that are predominantly fat with greater success [4]. This is one area in which breast pattern density classification is potentially useful.

The Breast Imaging Reporting and Data System (BIRADS) breast density categorization provides a means for such a classification. The American College of Radiologists suggests that breast composition should be reported in all patients using the BIRADS classification [1]. The classification categories are:

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1. The breast is almost entirely fat.
2. There are scattered fibroglandular densities.
3. The breast tissue is heterogeneously dense. This may lower the sensitivity of mammography.
4. The breast tissue is extremely dense, which could obscure a lesion on mammography.

Breast pattern classification algorithms [9] may be used, for example, to select mammograms belonging to the first BIRADS category in order that they can be evaluated by pre-screening. Of course, this is the category of image that human film readers can also dismiss most easily. However, a majority of women in the screening programme belong to the age group 50-69 years of age, for whom a large proportion have predominantly fatty breasts. It follows that the benefits of pre-screening this group of mammograms, if only in terms of radiologist time, are potentially significant.

2 Method

We have investigated the performance of a mammographic image analysis system developed recently by [7] by evaluating the performance of the algorithm on different breast density classes. The aim is to evaluate how the specificity and sensitivity of CAD systems can be affected when these systems are used only for the assessment of mammograms that belong a specific BIRADS category.

The algorithm developed in [7] proposes a segmentation method for delineating regions of interest (ROIs) in mammograms. A topographic representation, called the iso-level contour map is used, in which a salient region forms a dense quasiconcentric pattern of contours. The topological and geometrical structure of the image is analysed using an inclusion tree that is a hierarchical representation of the enclosure relationships between contours. The "saliency" of a region is measured topologically as the minimum nesting depth (Figure 1). The algorithm was developed for prompting suspicious regions independent of the density class the mammogram belonged to.

The results of the algorithm, along with the minimum nesting depth for detection, were available for the suggested assessment. They were based on a set of 400 mammograms with masses varying in size and subtlety selected from various pathological categories in the digital database for screening mammography (DDSM) database [5]. Since the aim of [7] was mass detection and breast segmentation, unfortunately, no normal cases were included in the available evaluations.

The mammograms are first classified into one of the four BIRADS classes. The detected regions, according to minimum depth, are used to create ROC (True Positive Fraction versus False Positive Fraction) curves in order to evaluate the performance of the algorithm under different breast pattern density scenarios.