Computer Aided Detection and Recognition of Lesions in Ultrasound Breast Images

Moi Hoon Yap, Loughborough University, UK
Eran Edirisinghe, Loughborough University, UK
Helmut Bez, Loughborough University, UK

ABSTRACT

The authors extend their previous work on Ultrasound (US) image lesion detection and segmentation, to classification, proposing a complete end-to-end solution for automatic Ultrasound Computer Aided Detection (US CAD). Carried out is a comprehensive analysis to determine the best classifier-feature set combination that works optimally in US imaging. In particular the use of nineteen features categorised into three groups (shape, texture and edge), ten classifiers and 22 feature selection approaches are used in the analysis. From the overall performance, the classifier RBFNetworks defined by the WEKA pattern recognition tool set, with a feature set comprising of the area to perimeter ratio, solidity, elongation, roundness, standard deviation, two Fourier related and a fractal related texture measures out-performed other combinations of feature-classifiers, with an achievement of predicted A value of 0.948. Next analyzed is the use of a number of different metrics in performance analysis and provide an insight to future improvements and extension.

Keywords: Breast, Classification, Feature Extraction, Segmentation, Ultrasound

INTRODUCTION

Early detection of cancer plays a vital role in reducing mortality rates. Therefore many countries have established screening programmes where citizen groups who are at higher risk of developing cancer are routinely monitored (National Health Service, 2008; Smith et al., 2003). For example, in the United Kingdom, screening is currently carried out using analogue films, with a rather small number of centres trialling computed radiology and full field digital mammographic screening. It is planned that by 2010 every screening centre will have at least one digital mammography unit. Therefore in the near future digital images and their computer aided analysis are likely to play a major role in screening, detection and treatment of cancer.

At present there are a number of research groups worldwide who are investigating breast sonograms. The main focus is to create automated, ultrasound, Computer Aided Diagnosis
(CAD) systems with high sensitivity, specificity and consistency. Despite these efforts CAD of ultrasound images still remains an area with many open research problems that needs solutions. In this article we identify a key open research problem in ultrasound imaging which is thoroughly investigated in order to develop a new method of ultrasound image processing for extracting relevant tissue structure information that will help differentiate between normal and malignant tissues. The ultimate goal is to provide fast and reliable tools for the early detection of malignant tissues in ultrasound images.

The current practical use of a typical US CAD system can be illustrated as in figure 1. The input of a CAD system consists of a rectangular region of interests, manually selected by a radiologist. The output provides a statistical analysis that can aid the radiologist in the final decision making, i.e., the malignancy and/or type of cancer.

The above approach (Figure 1) to CAD of breast ultrasound images has a limitation in that no aid is provided to the radiologist who selects the Region of Interest (ROI) of the lesions. Modern computer vision approaches can be used for fully automatic initial lesion detection, which can then be used as an aid to the decision making process of the radiologist, thus improving the accuracy of their performance. Further at this initial stage the need of a radiologist can be completely eliminated by allowing for a higher degree of false positives which can later be removed by further CAD or the presence of a radiologist at the final decision making stage.

Thus in this article we aim to use our previous work in initial lesion detection and segmentation to remove the need of a radiologist at the initial lesion detection stage and then propose a novel approach for the selection of lesion features and feature based lesion classification to automatically determine the lesion type. In particular within the research context of this article we aim to develop a framework for the selection of best feature-classifier combinations in US breast imaging. To the authors knowledge such an attempt has previously not been published in relevant literature.

The aims of our research are: (i) to automate the Region of Interest (ROI) selection and (ii) to improve the segmentation and classification algorithms. Figure 2 illustrates the above aims. It is important to note that both above automations will improve the information provided to the radiologist to aid in decision making (at the ROI cropping and final decision making stages, refer to Figure 1), improving the overall accuracy of the CAD system and reducing human error.

For clarity of presentation this article has been divided into 5 sub-sections. Apart from this section which provides the reader an introduction to the problem domain and setting out the objectives of the proposed research, State-of-the-art US CAD Systems section introduces a detailed review of the state-of-the-art in US CAD system research. Method section proposes the proposed end-to-end solution to US CAD, with particular emphasis given to the recognition stage. Experimental results and analysis section...
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