Microcalcification Detection in Full Field Digital Mammograms

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Abstract

In this paper we present a complete system to detect breast cancer. Main objective is to support radiologists with automatic, semantic based, search methods directly over medical images. The complete step of microcalcification detection in mammography images is presented. We use a three stage algorithm that allows the detection and classification of microcalcification with satisfactory results.

1. Introduction

Breast Cancer is a serious health threat to women. Studies conducted in the USA show that it is the second to lung cancer in cancer deaths among women [5]. Fortunately, treatments involving complete breast removal are rarely needed today, as better treatment options are available. Mammography can show changes in the breast up to two years before a physician can feel them. Screening mammography is currently the only proven and cost effective method that enables the efficient diagnosis of breast cancer at an earlier stage increasing the treatment options [1]. Computer-aided detection and diagnosis is considered to be one of the most promising approaches that may improve the efficiency of mammography. Furthermore, there is a strong connection between the presence of microcalcification and the occurrence of breast cancer.

2. Computer Aided Diagnosis

This work is being conducted under the Semantic PACS (Picture Archiving and Communication Systems) Project, which aims to develop a software module to integrate with current PACS that supports automatic, semantic based, description and search methods directly over medical images. In opposition with existent systems, we would like to make possible to generate on-the-fly diagnosis based on similarity of medical images archived in system. Currently, we are pursuing these ideas in the breast cancer domain.

2.1 Computer Aided Mammography

There are many different types of mammographic abnormalities that may indicate the presence of breast cancer. In our system, diagnosis is based on occurrence of microcalcifications and masses. We are using Breast Imaging Reporting and Database System (BI-RADS) developed by the American College of Radiology, which is a standard system to record such findings. The objective of the project is to develop a system that automatically classifies mammograms into BI-RADS scale.

Conventional CAD systems have four major steps in the detection and characterization of mammographic abnormalities. These steps encompass the Pre-processing, Feature Extraction, Feature Selection and Classification Stages.

To enable the development of the research in Computer Aided Mammography, and working in collaboration with Hospital de S. João, we started by creating a database of full-field digital mammograms. All images were manually annotated by a specialized radiologist.

3. Microcalcification detection

Microcalcifications usually come in clusters, having very sharp edges, and irregular shape of very small size. Due to their high attenuation properties of calcium, they appear as white (or high intensity) spots on mammograms.

The proposed microcalcification detection algorithm consists in three stages: pre-processing, detection, and classification of previously designated Regions Of Interest (ROIs), as shown in Figure 1.

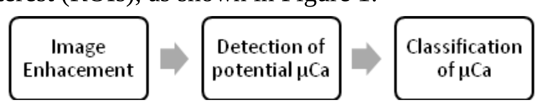

Figure 1. Algorithm overview

Image enhancement is preceded by a cropping operation on the original image. We investigated several algorithms of image enhancement to detect potential clusters of microcalcification. We started with a simple approach, where the image is filtered using a small median filter, smoothed and then subtracted from the original image. Another approach uses morphology transformations to detect potential microcalcifications [3]. Results of these enhancement techniques were not at a level of performance which could allow their use in a real application.

Microcalcifications are high frequency in nature, so they should be detectable with high pass filtering. We use non-sub-sampled contourlet transform. The algorithm is based on a non-sub-sampled pyramid structure and non-sub-sampled directional filter banks [2]. Such structure guarantees flexible, multi-scale and shift invariant image decomposition.

The last image enhancement method, that we investigated, is based on the phase preserving denoising algorithm proposed by Peter Kovesi [4]. This method differs from standard wavelet denoising techniques in that it uses non-orthogonal log-Gabor wavelets and, unlike other existing techniques, ensures that phase information is preserved in the image. This method gave us the best results so we use it in the final system.

In the second step, we use global thresholding to detect potential microcalcifications. In the output of that stage, besides the true microcalcification, a lot of noise and false positive microcalcifications are present.

The last stage begins with the extraction of 94 features for each suspicious block of size 16x16 that contain a suspicious microcalcification in the centre. Of the original 94 features, 90 come from the textural domain (Haralick Texture features, Gray Level Run Lengths and Law's Texture Energy Measures) and 4 from the spatial domain (skewness, kurtosis, standard variation and mean gray level).

In the classification step, we use Support Vector Machines. The training set consists in information from 136 mammography images (104 malignant and 32 normal).

4. Results

In Figure 2 we show some results from the enhancement stage.

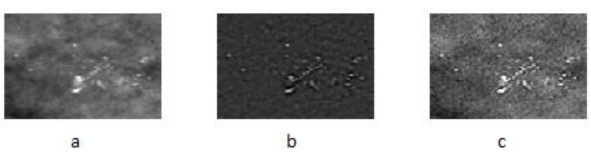

Figure 2. Enhancement. a) original image b) phase preserving denoising algorithm c) non-sub-sampled contourlet transform algorithm

Figure 3 shows results from the classification phase. Left image is the part of the image after the detection step, where a lot of noise and potential false positive findings are present. Right image is the output after the classification step.

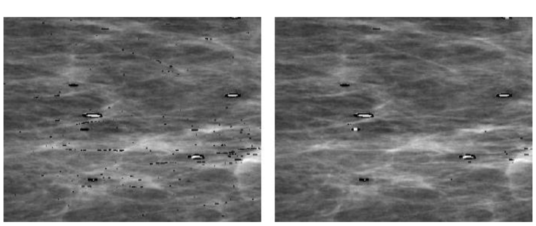

Figure 3. False positives elimination. left: suspected microcalcifications, right: output of the system

To evaluate the quality of the microcalcifications detection algorithm, we conducted a complete objective evaluation based on optimal assessment approach. Simple pixel by pixel comparison is not appropriate in this case.

For every calcification present in the output of the system, the evaluation algorithm tries to find a correspondence in the ground truth information. If it is possible, and the distance is not bigger than a specified threshold, the algorithm considers the microcalcification as correctly detected. Otherwise, it is counted as missed or false positive. The methodology proposed in this paper was assessed on a set of 20 mammograms. Obtained results are promising. Overall missing rate is 2.55 microcalcifications per image, sensitivity of the system is 77%, and false positives for image is 6.1.

5. Conclusion

The goal of the present work is to improve the quality of breast cancer detection. In this paper, we presented wavelet based techniques for automatically microcalcifications detection.

Future works involve the reduction of false positive findings and improvement of the sensitivity of the system. We believe this is possible thought the detection and remotion of linear structures in the mammography image. Also, segmentation of image, actually based on a fixed threshold, should be replaced by an automatic, adaptive method.

6. Acknowledgments

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7. References

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