PhD Thesis Title: 'Development of advanced computer methods for breast cancer image interpretation through texture and temporal evolution analysis'

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Graduation Date: 8 July 2016
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ABSTRACT:

Breast cancer is one of the most dangerous diseases that attack mainly women. Computer-aided diagnosis systems may help to detect breast cancer early, and reduce mortality. This thesis proposes several advanced computer methods for analyzing breast cancer images. We analyze breast cancer in three imaging modalities: mammography, ultrasonography, and thermography. Our analysis includes mass/normal breast tissue classification, benign/malignant tumor classification in mammograms and ultrasound images, nipple detection in thermograms, mammogram image registration, and analysis of breast tumors' evolution.

We studied the performance of various texture analysis methods so that the number of false positives in breast cancer detection could be reduced. We considered such well-known texture analysis methods as local binary patterns, histogram of oriented gradients, co-occurrence matrix features and Gabor filters, and proposed two texture descriptors: uniform local directional pattern, and fuzzy local directional pattern. We also studied the effect of factors such as pixel resolution, integration scale, preprocessing, and feature normalization on the performance of these texture methods for tumor classification. Finally, we used super-resolution approaches to improve the performance of texture analysis methods when classifying breast tumors in ultrasound images. The methods proposed discriminated between different tissues, and significantly improved the analysis of breast cancer images.

For the analysis of breast cancer in thermograms, we propose an unsupervised, automatic method for detecting nipples that is accurate, simple, and fast. To analyze the evolution of breast cancer, we propose a temporal mammogram registration method based on the curvilinear coordinates. We also propose a method for quantifying and visualizing the evolution of breast tumors in patients undergoing medical treatment that uses flow fields, ordered weighted averaging aggregation operators, and strain tensors. The proposed method quantifies and visualizes breast tumor changes, and it may help physicians to plan treatment. Overall, the methods proposed in this thesis improve the performance of the state-of-the-art approaches, and may help to improve the diagnosis of breast cancer.

References to author publications that relate specifically to the dissertation:

1-Mohamed Abdel-Nasser, Antonio Moreno, and Domenec Puig, ``Temporal mammogram image registration using optimized curvilinear coordinates,'' *Computer Methods and Programs in Biomedicine*, Volume 127, pages 1-14 (2016).

2-Mohamed Abdel-Nasser, Hatem A. Rashwan, Antonio Moreno, Luis Martin, Meritxell Arenas, Anna Magarolas, Lorena Diez-Presa, Joan Marti, and Domenec Puig, ``Breast Cancer Development Analysis In Follow-Up Digital Mammograms Through Anatomical-Based Variational Optical Flow: Preliminary Study,'' *International Journal of Computer Assisted Radiology and Surgery*, Volume 10 (Suppl 1): S1-S31 (2015).

3-Mohamed Abdel-Nasser, Hatem A. Rashwan, Domenec Puig, and Antonio Moreno, ``Analysis of tissue abnormality and breast density in mammographic images using a uniform local directional pattern,'' *Expert Systems with Applications*, Volume 42(24): 9499-9511 (2015).

4-Mohamed Abdel-Nasser, Antonio Moreno, and Domenec Puig, ``Towards Cost Reduction of Breast Cancer Diagnosis using Mammography Texture Analysis,'' J*ournal of Experimental &Theoretical Artificial Intelligence*, Volume 28(1-2): 385-402 (2016).

5-Mohamed Abdel-Nasser, J. Melendez, A. Moreno, and D. Puig, ``The impact of pixel resolution, integration scale, preprocessing and feature normalization on texture analysis for mass classification in mammograms,'' *International Journal of Optics*, Article ID 1370259, 12 pages, Volume 2016 (2016).