Mammographic Image Analysis for Tumoral Mass Automatic Classification

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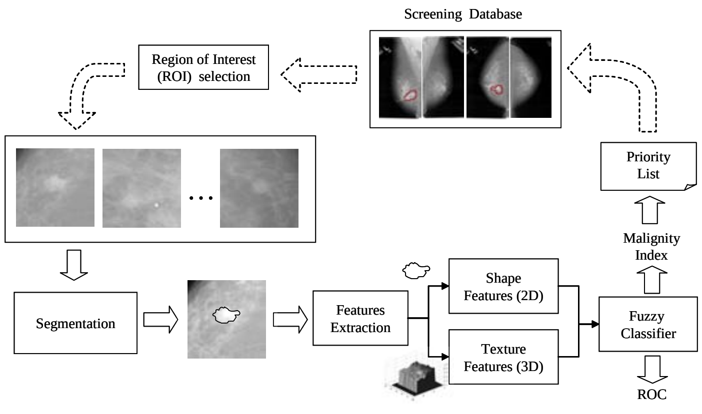
I. Introduction

Mammography is the most effective procedure for an early diagnosis of breast cancer, even if the detection of cancer signs is a difficult task owing to the great number of non pathological structures. Moreover, it has been shown that, in current breast cancer screenings, $10\%-25\%$ of the tumors are missed by the radiologists. Probably, the causes of these false-negative screening examinations are that the shape and dimension of the tumoral masses are often irregular, the borders are ill-defined, they are very low contrast signs, thus making difficult the discrimination from parenchymas structures. So, a preliminary segmentation procedure has to be implemented [1] in order to enhance the mass from background tissue. In this way, various characteristics of the segmented mass can be evaluated, in order to classify pathological and negative cases. Nowadays, the classification is done by human observation and the results are not always satisfying. Specialists classification of the available biopsies leads to 22% belonging to high level, 16.5% of low level and the remaining 61.5% are left unclassified, so that an automatic classification is needed, based on supplied parameters, beyond visual inspection. Several Artificial Intelligence (AI) techniques including neural networks and fuzzy logic are successfully applied in the area of medical diagnosis. The main advantage of fuzzy rule-based systems is that they do not require large memory storage, their inference speed is very high and the users can carefully examine each fuzzy if-then rule, so allowing a real time implementation. In particular, in the proposed work, we implement a classification procedure in order to assign a malignancy index to the mammographic images of a screening database, so that a priority list can be associated to the medical cases under study. This step should be very fast although the very high number of images in the database.

II. The whole procedure

The whole procedure is outlined in Fig. 1. The mammographic images are acquired (transmitted to a remote



(a)

SHAPE FEATURES	TEXTURE FEATURES	
Area: number of pixels of the mass.	Anisotropy: the distance between the geometric center and the center of luminosity.	
Perimeter: number of edge pixels.	Angular second moment	Haralick features
	Contrast	
Circularity: normalized ratio of the square of perimeter and area.	Correlation	
	Variance	
Rectangularity: ratio between the area of the mass and the area of the bounding box containing the mass.	Inverse difference moment	
	Sum average, variance, entropy	
	Difference variance, entropy	
	Information misures correlation	
Eccentricity: characterize the lengthening of a mass.	Max correlation coefficient	
	Sum entropy	

(b)

Fig. 1. (a) The whole segmentation and classification scheme. (b) Shape and texture features.

elaboration unit in a telemedicine system that store the database) and a Region of Interest (ROI) is manually or automatically selected by radiologists. Then, a preliminary segmentation [1] able to extract the contour of the mass,

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through a binary mask, is applied. This mask is obtained by an image analysis performed by wavelet transform [1], [2] and morphological operators [1], [3]. Through this mask, the mass is separated from background structures and proper features are computed: *shape features* [4] in a 2D space and *texture features* [5] in a 3D space. Table in Fig. 1(b) provides a preliminary selection of these indexes performed by a statistical analysis, applied on a large number of images, in order to identify the most discriminant features between pathological masses and negative cases [6]. The values of the selected features are then passed to a fuzzy classifier which assigns a malignancy level to the masses of the screening. This classifier uses a direct rule generator method that involves no time-consuming tuning procedures on breast cancer data, so that the classification step is very fast so that a real time implementation is possible.

III. Preliminary results

A preliminary validation of the proposed algorithm has been performed on mammographic images (LJPEG, gray scale, 12/16 bit resolution) taken from Digital Database for Screening Mammography (DDSM) [7]. In particular first results concerning the segmentation step and the extraction of mass boundary are provided. Figures 2(a)-(d) shows four examples of the mass contours extracted by our algorithm compared with contours outlined by radiologists. Note that the accuracy of our method increases as contrast decreases so that the CAD successfully assist radiologists in diagnosis.

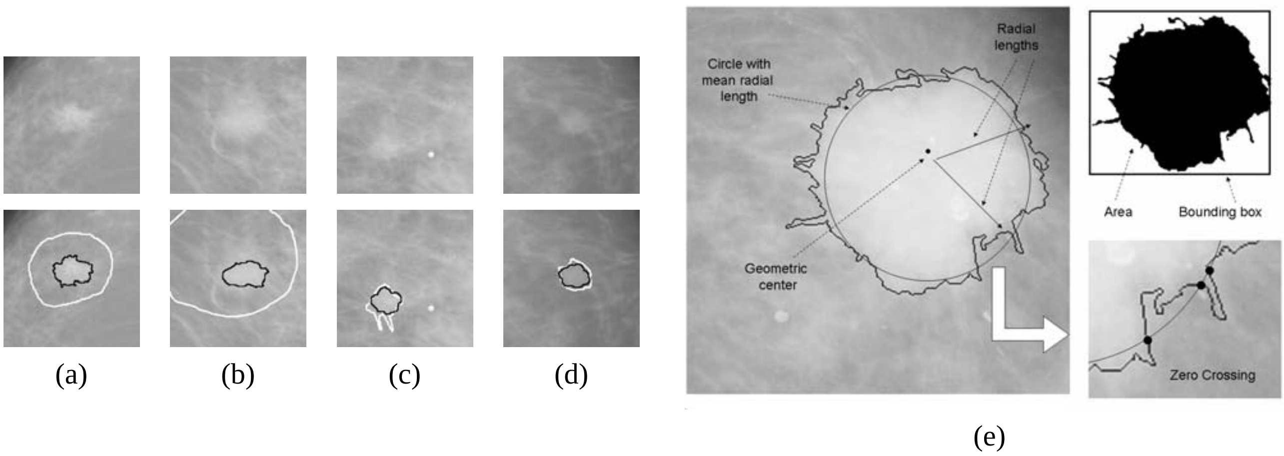

Fig. 2. (a)-(d) Comparison between the mass contour identified by the radiologist (white line) and the one detected by our algorithm (black line). (e) Shape features (Geometric center, radial distance, zero crossing, and rectangularity).

Finally, Fig. 2(e) shows some examples of shape indexes evaluated on a particular tumoral mass, such as geometric center, radial distance, circle with mean radial length, boundary roughness, rectangularity.

In the final paper we will show the results of the fuzzy classification performed on 150 cancer cases and 150 benign cases taken from DDSM [7] and we will compare our method with other classification techniques, such as artificial neural networks and linear classifiers.

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