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A new approach for the detection of mammary calcifications by using the white Top-Hat transform and thresholding of Otsu

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ABSTRACT

The mammography is the technique of imagery the most used to detect tumors at an early stage, it is currently the principal investigation in the tracking of the breast cancer. The presence of calcification in mammography is particularly interesting for the early detection of the breast cancer. In this paper, we propose to use a system for the detection of calcifications, based on a new approach suggested of pretreatment of image mammography. The latter is based on the suppression of noise (to decrease the noise to the maximum) by a Gaussian filter in order to bring out all the spots (Clear Spots) possible to be calcifications; by using an operator of the white Top-Hat transform. This hat is resulting from the mathematical morphology, which makes it possible to keep only these small structures. The segmentation by the simple technique of Otsu [1] is then used in order to separate detected calcifications. Visually, the obtained results are very clear, and show the good performance of the new approach suggested in this work. This latter allows extracting successfully the calcifications starting from the mammography referents from the mini-MIAS database [2].

1. Introduction

Research in medical imagery is one of the most active disciplines of the image processing. These recent discovery allows not only a better diagnosis but also offers new hopes of treatment for many diseases (like the breast cancer). Indeed, the breast cancer constitutes the most common cause of death women [3]. Particularly in Algeria, every year about 10,000 new cases are detected mostly in the 40 s (forties). 95% of the cases arise at an advanced stage of pathology [4]. The stage of the diagnosis is a key stage in the struggle against the breast cancer as for any other pathology. Consequently, the detection of cancer, the analysis and the treatment of cancer became a major research orientation. The modern imagery technology has already had on the rescue early cancer detection capacity, and more precisely, the diagnosis of the disease. For this reason, the radiological technique the most effective is mammography [5–7]; particularly, lesions on the level of the breast. According to the radiologists an important indicator of the breast cancer is the presence of calcifications which appear in 30% to 50% of the cases diagnosed by mammography [8–11]. The mammography is a technique with low dose of X-rays that does not allow a good visualization of the internal structure of the breast. These difficulties and the low quality of mammographic images are making that analysis is particularly tiring and wasting time. Consequently, the design of a system of computer-aided detection (CAD) represents a system to help the radiologists in the interpretation of the mammography for the tracking of mass and calcification [12]. In spite of efforts made by the researchers, the automation of detection of mammary pathologies remains always difficult. During last years, there were significant efforts in the development of algorithms for the detection of calcifications in the images of mammography. Among the method the most important are those which use the representation of mammography based on the improvement of contrast and the detection of calcifications by the Top-Hat transform morphological [3,11,13,14]. Other improvements of contrast based on the Top-Hat transform but they are applied to different types from the images to levels of gray [15,16]. This last provides tools for the extraction of calcifications even if calcifications are located on a non-uniform background. Other studies have been conducted on mammography image for the local contrast enhancement [17,18] and the noise equalization [19], these latter are very important process in the stage of pretreatment of the images to increase contrast between the clear and dark zones to reveal the characteristics of the limits, the main aim of clearness of the image is to highlight fine details. There is also a method based on the wavelet transform to detect the calcifications gathered in mammography [20–24]. This transform offer a method of a very

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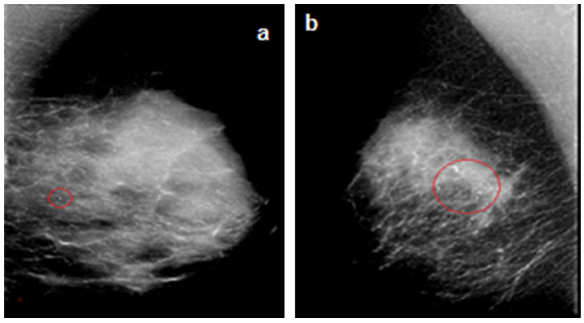

Fig. 1. Examples of mammography: (a) red circle indicates the macro-calcifications zone; (b) red circle indicates the micro-calcifications zone. (For interpretation of the references to color in figure legend, the reader is referred to the web version of the article.)

sparse and effective representation for the mammography, and it is regarded as being a mixture of several basic functions obtained by contractions, dilations and translations from the mother wavelet.

In this paper, a prototype of a system of detection of mammary pathologies, in particular calcifications, was put in work. For this reason, we propose a new approach to improve the detection of calcifications in the digitized mammography. This approach is based on two principal stages, suppression of the noise by the filter Gaussian and the improvement of contrast between calcifications and the background digitized mammography. We will make an effort in the improvement of contrast by the operations of the mathematical morphology (by using a morphological transformation White Top-Hat), which was used like a first stage of image processing. In the second phase, we use a segmentation of the area of interest for the identification of calcifications, based on the threshold of Otsu [1]. The method suggested has been tested on several images from the mini-MIAS database of mammograms [2], noting that the obtained results validate the superiority of our proposed approach.

The rest of this paper is structured as follows: Section 2 briefly presents basic information on calcifications in the mammography image. Section 3, we present our approach of detection of calcification by the improvement of contrast. Section 4 presents a very simple method for the segmentation of calcifications. The obtained experimental results are presented in Section 5. Finally, our conclusions are presented in the last section.

2. Basic information on calcifications

The presence of calcifications which generally seem luminous spots in mammary tissue, are tiny calcium deposits [25,26]. It is usual to distinguish two great types of calcifications according to the size: macro-calcifications and micro-calcifications [25,26]. The sizes of micro-calcifications (Fig. 1a) are in the range of 0.1–1.0 mm with an average diameter of approximately 0.5 mm [26]. Once their size exceeds 1.0 mm, they are macro-calcifications (Fig. 1b) [10], these last, are often benign whereas micro-calcifications require more attention. The luminous spots in the mammography with a diameter lower than 0.1 mm are considered as a noise of high frequency [10].

3. Detection method

This section presents the procedure of detection that is used in this work. It is summarized in Section 3.1 and the detail of each stage of this proposal is explained in the following sections.

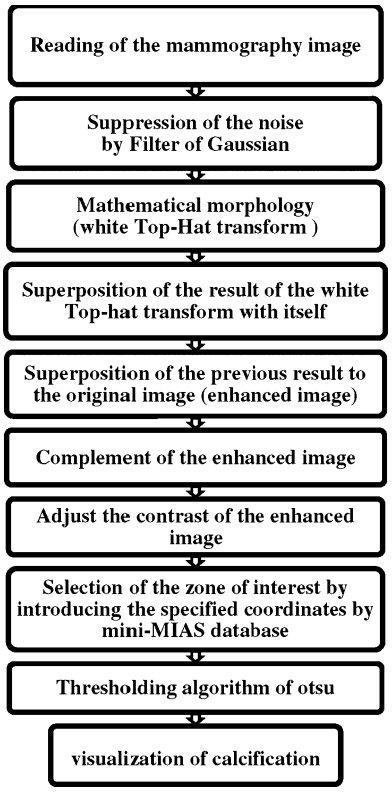

Fig. 2. Diagram of the proposed algorithm for the detection of calcifications.

3.1. The proposed Algorithm for the detection of calcifications

The diagram presented in Fig. 2 summarizes the several stages that we have proposed in our approach for detecting the calcifications.

3.2. Pretreatments

In spite of effort made by the researchers, the automation of the mammary pathologies detection remains always difficult. In this work, we propose a digital technique of pretreatment of the image based on the three following stages:

3.2.1. Stage (1): noise suppression

As calcifications are spots of small size and often of low intensity, designing a filter which is able to distinguish them from noise is very difficult. We call this initial filtering smoothing “fine”, simply because it modifies a little bit the information that we are seeking to locate.

We consider the Gaussian distribution that is given by the following expression:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{(x-\mu_1)^2+(y-\mu_2)^2}{2\sigma^2}} \quad (1)$$

with σ is the standard deviation and μ is the average.

Gaussian filtering uses this distribution to define a convolution filter. As we work on the discrete images, we propose to use a discrete approximation of the Gaussian distribution in a finished filter of convolution.

In this case, we considered a Gaussian filter of standard deviation of $\sigma = 0.5$ to reduce the noise present in the image mammography (see Fig. 3a) and to keep only the significant peaks. The resulting image is presented in Fig. 3b.