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Research paper

Local breast density assessment using reacquired mammographic images

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ABSTRACT

Purpose: The aim of this paper is to evaluate the spatial glandular volumetric tissue distribution as well as the density measures provided by Volpara™ using a dataset composed of repeated pairs of mammograms, where each pair was acquired in a short time frame and in a slightly changed position of the breast.

Materials and methods: We conducted a retrospective analysis of 99 pairs of repeatedly acquired full-field digital mammograms from 99 different patients. The commercial software Volpara™ Density Maps (Volpara Solutions, Wellington, New Zealand) is used to estimate both the global and the local glandular tissue distribution in each image. The global measures provided by Volpara™, such as breast volume, volume of glandular tissue, and volumetric breast density are compared between the two acquisitions. The evaluation of the local glandular information is performed using histogram similarity metrics, such as intersection and correlation, and local measures, such as statistics from the difference image and local gradient correlation measures.

Results: Global measures showed a high correlation (breast volume $R = 0.99$, volume of glandular tissue $R = 0.94$, and volumetric breast density $R = 0.96$) regardless the anode/filter material. Similarly, histogram intersection and correlation metric showed that, for each pair, the images share a high degree of information. Regarding the local distribution of glandular tissue, small changes in the angle of view do not yield significant differences in the glandular pattern, whilst changes in the breast thickness between both acquisition affect the spatial parenchymal distribution.

Conclusions: This study indicates that Volpara™ Density Maps is reliable in estimating the local glandular tissue distribution and can be used for its assessment and follow-up. Volpara™ Density Maps is robust to small variations of the acquisition angle and to the beam energy, although divergences arise due to different breast compression conditions.

1. Introduction

Each year in Europe, 500,000 new cases of breast cancer are diagnosed and 143,000 women die from this disease [1]. In order to reduce this mortality, early breast cancer detection is a pivotal step, since its treatment would be less aggressive and more effective [2]. X-ray mammography remains considered the gold standard imaging technique in early disease detection, and is widely used in national screening programmes [3,4]. The latest trends in breast cancer research, however, indicate a willingness to develop a more personalised screening [5].

Volumetric breast density (VBD), among other biomarkers such as diet [6] or physical activity [7], has shown a high correlation with the development of breast cancer and has been established as an important risk factor [8,9]. This has motivated the investigation of women stratification strategies in screening programmes based on breast density.[1] Furthermore, several software tools have been developed to estimate breast density from X-ray mammographic images. These include Volpara™ (Volpara Solutions; Wellington, New Zealand),[2] Quantra™ (Hologic; Danbury, Connecticut, USA)[3] and CumulusV (University of Toronto; Toronto, Canada) among others.

In addition to global measures such as the VBD, the local density

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[1] ASSURE project: http://assure-project.eu.
[2] http://volparasolutions.com/.
[3] http://www.hologic.com/.

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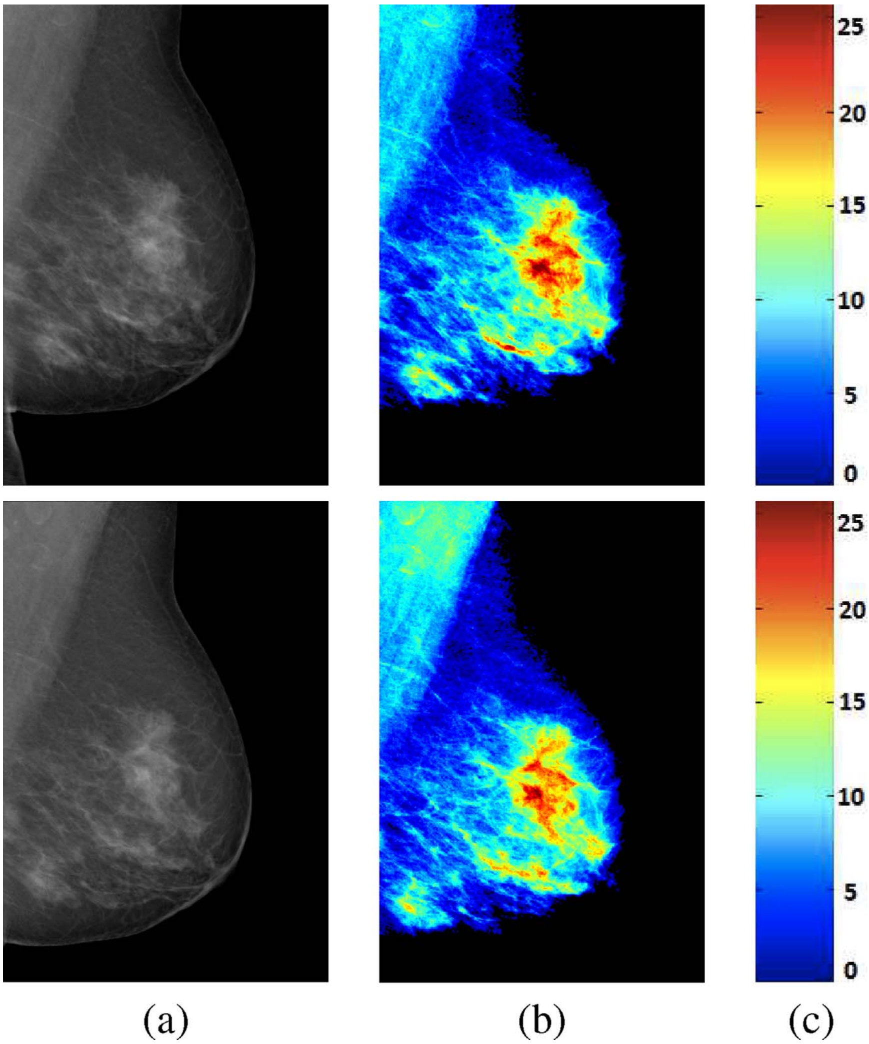

Fig. 1. (a) Mammograms and (b) the corresponding density maps (right). The colour scale in (c) shows the amount of glandular tissue in millimetres. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

distribution and the parenchymal patterns can provide complementary information for risk assessment and disease development [10,11]. However, performing an automatic evaluation of the spatial distribution of the glandular tissue is a challenging task. On one hand, few algorithms provide pixel-wise information about the breast glandularity. On the other hand, several factors, such as the breast compression or temporal changes (aging, involution, hormonal interactions) [12], can modify the appearance of the mammogram as well as the automatic density measures.

The aim of this paper is to evaluate the repeatability of the glandular tissue measures provided by Volpara™ Density Maps (v.1.5.11). Volpara™ uses the physics-based model proposed by Highnam et al. [13] to extract pixel-wise information from the raw mammograms (i.e. “for processing”). Global density measures provided by Volpara™ have already been validated against magnetic resonance imaging (MRI) [14] and computed tomography (CT) images [15]. Furthermore, its reliability has also been investigated, comparing favourably versus a reference standard two-dimensional area-based method [16]. However, few attempts have been performed for evaluating the density maps (*DM*) obtained using this software. As is shown in Fig. 1, the density maps shows the distribution of the dense tissue in the breasts.

Here, we use repeated mammograms for quantitatively assessing the variation of the density maps. To our knowledge, this is the first study analysing the results of Volpara Density Maps using mammograms of the same breast acquired in few minutes of difference. Notice that, in this case, there is not a change in the glandularity of the breast, although several factors, such as different breast compression or different acquisition parameters, can modify the appearance and density measures of the breast.

2. Materials and methodology

The dataset was composed of 99 pairs of mammograms (198 FFDMs in total) from 99 patients, including 56 pairs of CC and 43 pairs of MLO projections. The dataset was acquired between 2008 and 2016 at the Radboud University Medical Center (Nijmegen, The Netherlands) and Hospital Universitari Parc Taulí (Sabadell, Spain). Women were between 30 and 76 years old, and the average age was 52.32 ± 13.61. Regarding the mammographic devices, a GE Senographe (GE Healthcare™; Chicago, USA) was used at the Radboud Medical Center while a Hologic Selenia Dimensions system (Hologic™; Massachusetts, USA) was used at Parc Taulí Hospital.

The FFDMs were acquired for screening purposes of high-risk women, i.e. high familiar or genetic risk in standard clinical settings (e.g. use of an anti-scatter grid and automatic exposure control) and considering the quality assumptions exposed in the European guidelines [17]. In this retrospective study, each image pair corresponded to mammograms acquired within a very short time interval (of few minutes). Mammograms were repeated due to obtaining a suspicious area that prompted the radiologists to slightly change the position of the breast. This is a common procedure in clinical practice, where the goal of the second acquisition is to re-analyse a possible finding that might be due to tissue superposition. This means that the second projection is on purpose a little bit rotated compared to the first. Hence, the patient