Computer-Aided Detection of Lesions in Digital Breast Tomosynthesis Images

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Abstract. The most common cancer among women in the western world is breast cancer. Early detection of lesions greatly influences the progress and success of its treatment. Digital breast tomosynthesis (DBT) is a new imaging technique that facilitates a three-dimensional reconstruction of the breast. DBT reduces superimposition of breast tissues and provides better insight into the breast compared to the common digital mammography. In order to assist radiologists with the examination and assessment of the large amount of DBT data, a computer aided detection (CADe) of focal lesions can be an essential tool, leading to increased sensitivity and specificity. We present and compare two different approaches for a fully automated detection of lesions in DBT data using voxel-wise classification, one being the state of the art and the other one an enhancement. Multiple difference of Gaussians detect lesions based on their common higher intensity and contrast in relation to surrounding tissue. A gradient orientation analysis detects round and spiculated lesions, even when they are weak in contrast and intensity. By combining these features and using a support vector machine, a classification performance of 88% can be achieved.

1 Introduction

Worldwide, breast cancer is the most common cancer among women and represents the leading cause of mortality for women in their fifties [1]. The early detection and appropriate treatment of lesions considerably increases the chance of survival. The 5-year survival rate for patients with breast cancer in early stage has been reported with up to 97% [2]. In the late stage this rate drastically decreases to about 23% [2]. To date, mammography is the only image based technique for early detection of breast cancer that verifiably decreases the mortality rate [3]. Mammography utilizes low dose X-Rays for the acquisition of high resolution X-Ray images of the breast. Lesions are possible indications for breast cancer. They are most often depicted as conspicuous bright areas on the X-Rays since they commonly have a higher density compared to surrounding

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healthy tissue. Unfortunately, 10 to 30% of breast cancer cases remain undetected in conventional mammography due to overlapping tissue and low contrast lesions that occur especially in dense breasts [2]. Digital breast tomosynthesis (DBT) is a new imaging technique that resembles computed tomography (CT) in a way that a series of X-Ray images are acquired by shifting the X-Ray emitter along an partial arc around the breast. A series of X-Ray images are then used to three-dimensionally reconstruct the breast. The DBT acquisition and some three-dimensional reconstructed slices are depicted in Fig. 1. This imaging technique considerably decreases the amount of overlapping tissue and hence provides better insight into the breast. A survey among radiologists shows that DBT provides comparable (to 51%) or better image quality (to 37%) in 89% of all considered cases in comparison to conventional mammography [5].

Manual screening for lesions and signs of breast cancer in DBT or digital mammograms is a time consuming and complex task which is prone to mistakes by the examining radiologist [3]. In this process, a computer aided detection (CADe) system becomes an important tool for supporting the clinical examination and clinical decision making. Studies show that a CADe system may increase the detection rate of lesions about 20% [6]. It is capable of providing an objective second opinion of constant quality, reducing the workload of radiologist and saving time and costs. In this work we present a CADe system that reads available DBT data and highlights all voxels that are likely to belong to a lesion. The more likely a region in the DBT mammogram belongs to a lesion, the brighter it gets highlighted in the feature map. The sensitivity and specificity of the output remains controllable by the radiologist to fit personal preferences.

2 Materials and methods

The overall process of the developed CADe system consists of two parts. The first part classifies all voxels separately in possible lesions and non-lesions pur-

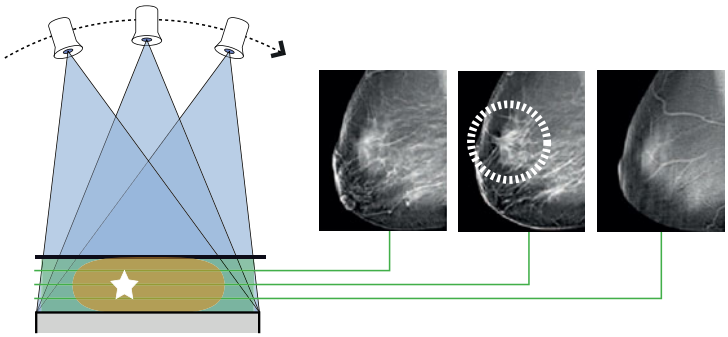

Fig. 1. Scheme of a DBT acquisition of a compressed breast (left) and the output slices (right). The lesion (white star) in the breast is clearly visible in the center slice (white circle). After [4].