Removal of Pectoral Muscle Region in Digital Mammograms using Binary Thresholding

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ABSTRACT

The pectoral muscle represents a predominant density region in Medio-Lateral Oblique (MLO) views of mammograms, which appears at approximately the same density as the dense tissues of interest in the image and can affect the results of image analysis methods. Therefore, segmentation of pectoral muscle is important in order to limit the search for the breast abnormalities only to the breast region. In this paper, a simple and effective approach is proposed to exclude the pectoral muscle based on binary operation. The performance is analyzed by the Hausdorff Distance Measure (HDM) and also the Mean of Absolute Error Distance Measure (MAEDM) based on differences between the results received from the radiologists and by the proposed method. The digital mammogram images are taken from MIAS dataset which contains 322 images in total, out of which the proposed algorithm able to detect and remove the pectoral region from 291 images successfully.

Keywords: Digital Mammography, Film Artifact, Hausdorff Distance Measure (HDM), Medio-Lateral Oblique (MLO), Pectoral Segmentation

1. INTRODUCTION

There are more than one million new cases of breast cancer occurring annually around the world with the incidence rising steadily. Breast cancer has been replacing cervical cancer as the leading site of cancer in most urban population based cancer registries in India. The cause of this disease is not clear and neither are the reasons for the increased number of cases. Currently there are no methods to prevent breast cancer, which is why early detection represents a very important factor in cancer treatment and allows reaching a high survival rate. Mammography is considered the most reliable method in early detection of breast cancer. Computer aided interpretation of mammogram images is used as the second opinion for radiologists. There are number of methods have been reviewed for early detection of breast cancer (Thangavel et al., 2005). The Computer-Aided Detection (CAD) system consists of several modules, such as preprocessing, segmentation, feature extraction and classification. This paper focuses on the first module, the preprocessing, here the important features of the mammogram are
enhanced, recovering most of the hidden characteristics and improving image quality also to improve the classification accuracy. Before the mammograms are subjected to analyze, the breast region has to be segmented. The breast region contains a predominant density region called pectoral muscle in Medio-Lateral Oblique (MLO) views of mammograms. This region must be removed from the breast region in order to improve the performance of the computer-aided diagnosis of mammograms. When the MLO view is properly analyzed, the pectoral muscle always appears a high-intensity and triangular region across the upper margin of the image. The other view of mammograms is Craniocaudal (CC) view, which has not been considered in this paper because the pectoral muscle is only seen in about 30%-40% of CC images (Eklund, Cardenosa, & Parsons, 1994). Automatic pectoral muscle segmentation is useful in many areas of mammographic analysis. Gupta and Undrill (1995) indicated that malign tissues and the pectoral muscle region may have similar texture characteristics, increases number of false positives when detecting suspicious masses. Also the area overlying the pectoral muscle is a common area for cancers to develop and is particularly checked by radiologists to reduce false negatives. Therefore it is necessary to segment the pectoral muscle before mass detection (Hatanaka et al., 2001). Similarly, exclusion of the pectoral muscle is required for automatic breast tissue density quantification (Karssemeijer, 1998; Saha et al., 2001). The pectoral edge is also used as one of the axes in 3-dimensional reconstructions from multiple mammographic views (Georgsson, 2001; Yam et al., 2001); and it is one of the pivotal landmarks in mammogram-pair registration and comparison (Miller & Astley, 1994).

Karssemeijer (1998) proposed the Hough transform to detect the pectoral edge, assumes that the pectoral edge is approximately a straight line oriented in a certain direction. To ensure that the correct peak is selected in the Hough space, gradient magnitude and orientation, length of projected line, and corresponding pectoral area were taken into account. Because of this careful selection scheme, the results were claimed to be very robust and reliable (Karssemeijer, 1998). Other recent studies based on the Hough transform include: Ferrari et al. (2001) who segmented mammograms into skin-air boundary, fibro-glandular tissue, and pectoral muscle; Yam et al. (2001) who refined the Hough transform linear approximation into a curved pectoral boundary using a dynamic programming method; and Georgsson (2001) who extracted the pectoral muscle by region growing with the Hough transform to be more reliable. There are several other approaches to segment the pectoral muscle. Suckling et al. (1995) segmented mammograms into four major components: background, pectoral muscle, fibro-glandular region and adipose region, using multiple, linked self-organizing neural networks. Aylward et al. (1998) used a gradient magnitude ridge traversal algorithm at a small scale to extract multiple initial points and then resolved the resulting multiple edge definitions via a voting scheme. Their method parallels that of Karssemeijer (1998). Sinha et al. (1999) reported a semi-automatic method that requires input from an operator to locate the pectoral muscle; delineation is then performed automatically. Chandrasekhar and Attikiouzel proposed two techniques to enhance the pectoral muscle region on mammograms: the extended Russ operator (Chandrasekhar & Attikiouzel, 2000) and tunable parametric edge detection, although final segmentation on the enhanced images had not been carried out.

In summary, almost all of the previous work approximates the pectoral edge as a straight line and then refines that straight line into a more accurate curved boundary, if needed. The accuracy of straight line approximation is usually good. With the Hough transform, the pectoral muscle was segmented in 92.8% of the mammograms tested in Karssemeijer (1998); and the pectoral muscle was accurately detected in 87.9% of the images within a difference of 1–3 mm in Ferrari et al. (2001). However the reliability of curve refinement has not been specifically tested and reported in the literature. Kwok et al. (2004) presented straight line estimation...