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Clinical Imaging 37 (2013) 498–503

CLINICAL IMAGING

Automatic detection of lesions in lung regions that are segmented using spatial relations

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Received 9 April 2012; received in revised form 18 July 2012; accepted 25 July 2012

Abstract

This article presents a novel approach for the automatic detection of lesions and selection of features on chest radiographs. We have illustrated the importance of accurate segmentation, which is based on spatial relationships between the lung structures, as a preprocessing step in a Computer Aided Diagnosis (CAD) scheme. Then, three suitable combinations of features have been identified using the forward stepwise selection method from the original images and their transformed ones. Experimental results show that our segmentation approach and the suppression of skeletal structures improve the detection accuracy. The selected features can describe efficiently different kinds of chest lesions.

Keywords: Chest radiography; Lesion detection; Feature selection; Segmentation

1. Introduction

By 2020, four of the seven major killers worldwide are expected to be lung diseases [1]. Despite the considerable progress of the computed tomography (CT) in the detection of pulmonary lesions, radiologists have not renounced the use of the radiographic image. Indeed, radiography continues to be the most widely used imaging technique of the initial detection of chest diseases [2] because of its low cost, simplicity, and low radiation dose. The detection of lesions on chest radiographs is an important task for radiologists, but they may fail to detect them because subtle lesions tend to be low in contrast and often overlap with ribs and clavicles [3]. That is why the development of a reliable computer-aided diagnosis (CAD) system for lung disease is one of the most important research topics in the area of medical image processing. There are two major problems related to the automatic detection of lung lesions in chest radiography: the large number of false positives and the great computation time [3]. An additional problem related to the detection of lesions is their classification. In fact, in most studies, the classification was limited to the distinction between the cancerous lesions from the non-cancerous. However, the lesion can be classified as an infection, tuberculosis, etc. A key stage of nodule detection and classification by CAD schemes is feature analysis and extraction [4]. The feature space is very large and complex due to the wide diversity of normal tissues and variety of abnormalities. Hundreds of features might be derived from an image, but not all of the features are suitable for lesion detection and classification. The purpose of our research is to develop a novel CAD system for automatic detection and classification of lung lesions in chest radiographies. Since the performance of the classifier depends directly on the ability of characterization of candidate regions by the adopted features, this paper focuses on detecting of regions candidates and finding the features from multi-scale chest radiographs.

This paper is organized as follows. Section 1 provides an overview on the related research works which have been carried on various techniques for lesions detection. In Section 2, we present the computerized scheme for automated detection of lung lesions. In Section 3, some

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http://dx.doi.org/10.1016/j.clinimag.2012.07.010

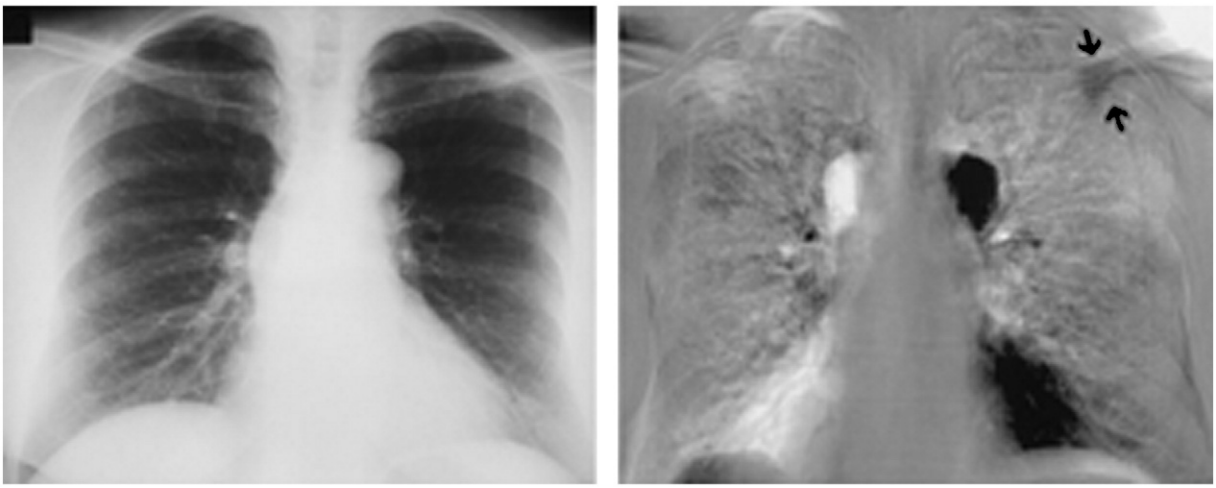

Fig. 1. Chest image and corresponding subtraction image [3].

final results are shown and discussed, and finally, in Section 4, conclusions are presented.

2. Related works

This paper presents a novel approach for the automatic detection of lesions and selection of features that can describe efficiently different kinds of chest lesions on chest radiographs. We present in this section the research works which have been devoted to the study of systems aimed to lung nodules detection. When trying to subdivide the literature, we discern two main areas:

- The purpose of the first class of CAD is to enhance chest radiograph in order to cancel out symmetrical skeletal structures such as ribs and thus can demonstrate a subtle lesion clearly. This approach would improve the diagnostic performance of radiologists detecting especially small nodules (see Fig. 1).
- The purpose of the second class aims to direct the radiologist's attention by identifying and indicating suspected focal opacities that may represent lesion on a radiograph. The combination of CAD scheme and radiologists' knowledge would then improve significantly the detection and classification accuracy (see Fig. 2).

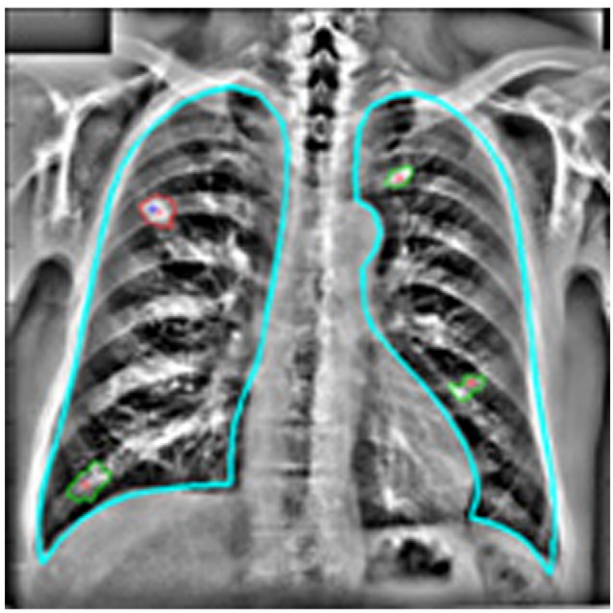

Fig. 2. A CAD output showing the nodules detection [2].

For the first class, a variety of subtraction techniques has been proposed for the enhancement of plain chest radiographs.

Among these techniques is the dual-energy subtraction (DES) technique for chest radiography that was studied in Ref. [5]. It can remove overlying bone structures to create soft-tissue images. It enhances the visualization of pulmonary nodules overlaid by bones. The radiologists' performance in detecting pulmonary lesions on chest images is then evaluated without and with the DES technique.

In Ref. [3], the authors have developed a contralateral subtraction technique for enhancement of asymmetric opacities on chest radiographs by using subtraction of a reversed "mirror" image from the original. Their purpose was to evaluate the potential usefulness of the contralateral subtraction technique for radiologists' performance in the detection of subtle lung nodules on chest radiographs.

The effect of rib suppression with a massive-training artificial neural network has been investigated on the performance of radiologists in the detection of pulmonary nodules on chest radiographs in Ref. [6].

The researchers have suggested in Ref. [7] to determine the value of dual-energy images in combination with conventional chest radiography in the detection of lung nodules and their classification as malignant or benign.

The second class relies on automatic detection of chest nodules. There are two variants of studies.