Chapter 35

Techniques for the Automated Segmentation of Lung in Thoracic Computed Tomography Scans

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ABSTRACT

Computed Tomography (CT) is widely used to diagnose and assess thoracic diseases. The improved resolution of CT studies has resulted in a substantial increase of image data for analysis by radiologists. The time-consuming nature of this analysis motivates the application of Computer-Aided Diagnostic (CAD) methods to assist radiologists. Most CAD methods require identification of the lung within the patient images, a preprocessing step known as “lung segmentation.” This chapter describes an intensity-based lung segmentation method. The segmentation method begins with simple thresholding, and several image processing modules are included to improve segmentation accuracy and robustness. Common segmentation difficulties are discussed and motivate the inclusion of each module in the lung segmentation method. These modules will include brief explanations of common techniques (e.g., morphological operators) in addition to novel techniques developed specifically for lung segmentation (e.g., gradient correlation filters).

INTRODUCTION

Computed Tomography (CT) of the thorax is used to diagnose and assess numerous thoracic diseases such as mesothelioma, emphysema, pulmonary embolism, and lung nodules (Armato & Sensakovic, 2004; Morgan, 1992; Mastuani, MacMahon, & Doi, 2002; Sensakovic, et al., 2011; Zhou, et al., 2005). The availability of multidetector-row, fan-beam, and cone-beam CT scanners has improved image resolution and decreased scanning time, thus expanding the role of CT in the diagnostic assessment of patients. The improved resolution has resulted in substan-
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Lung segmentation is essential for accurate analysis of thoracic CT scans. The segmentation of lung voxels is necessary to focus on pathological regions such as nodules or emphysema, reducing the risk of misdiagnosis (e.g., aortic calcification mistaken for lung nodule). Additionally, segmenting the lung voxels limits computation time by focusing on a fraction of the thoracic CT scan. The lungs, being prominent high-contrast structures within the thorax, can be used as guides for the segmentation of other structures such as the heart or pleura. The accuracy of lung segmentation is critical for accurate quantification of lung volume, which is essential in assessing conditions like emphysema. Inaccurate segmentation can lead to errors in assessment.

Lung segmentation in CT scans is a well-researched area, with various methods and techniques being developed. Intensity-based methods are widely used due to the high contrast between lung parenchyma and surrounding tissues. These methods include thresholding, active contours, and graph cuts, which are applied to the CT scan to identify lung candidates voxels. The segmentation method described begins with simple thresholding and includes several image processing modules to improve accuracy and robustness. Common difficulties in lung segmentation are discussed to motivate the inclusion of each module in the method.

OVERVIEW OF THE LUNG SEGMENTATION METHOD

The lung segmentation method assumes that the thorax and airway (i.e., trachea and bronchi) have been previously segmented. The segmentation begins by removing all voxels outside the segmented thorax, excluding non-anatomic structures like the CT scanning table. The airway, having similar Hounsfield Units (HU) to lung parenchyma, is removed using the segmented airway. An intensity threshold of (-10000 HU, -200 HU) is applied to the scan to retain lung candidates voxels.