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Keio University

Thesis Abstract

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Thesis Title

Computer Aided Diagnosis of Emphysema Based on Multi-Slice X-Ray CT Using Multi-Threshold Classification and Bullae Distribution Analysis

Thesis Summary

Classical computed tomography (CT) based methods for measuring emphysema include the pixel index (*PI*), mean lung density method, bullae (a bulla is a continuous low attenuation area in the CT) index (*BI*) and texture-based methods. These methods are subject to some limitations. The goal of this research is to devise more efficient emphysema describing features.

The threshold range from approximately -920 to -980 Hounsfield Unit for extracting emphysema from CT has been reported in many papers. However, correlation analyses between *PI*s of different thresholds and the parameters of pulmonary function tests show that a threshold which is useful for the CT data set A might not be useful for the CT data set B. Consequently, the author proposes a multi-threshold method. The author divides the lung into eight sub-volumes. From each sub-volume, the author calculates the ratio of the voxels with intensity below a certain gray-level threshold. A total of ten thresholds are determined. The respective ratios of the voxels below the ten thresholds are used as the features for classifying the sub-volumes of the lung into four classes of emphysema severity. Neural network is used as the classifier. The author shows that the multi-threshold method performs better than the classical methods in correlation with the parameters of pulmonary function tests. The author also implements 3D visualization of emphysema using the proposed transparent lung model.

Features generated from the former texture-based methods are not expressive for describing emphysema. The author proposes a method called low-attenuation gap length matrix (LAGLM). The LAGLM method is inspired by but different from the former texture-based methods. Features generated from the LAGLM method are more closely related to the definition of emphysema and therefore easier to interpret. The LAGLM method is used to classify the regional radiographic lung regions into four emphysematous patterns distinguishing, in particular, radiographic patterns that imply obvious or subtle bullous emphysema from those that imply diffuse emphysema or minor destruction of airway walls. Neural network is used for discrimination.

Classical methods including the former texture-based methods are not expressive for describing the distribution of bullae in the lung. Consequently, the author proposes an emphysema describing index called bullae congregation index (*BCI*) that describes whether bullae gather in a specific area of the lung and form a nearly single mass, and if so, how dense the mass of bullae is in the lung. The *BCI* is calculated based on the relative distance between every pair of bullae and the sizes of bullae in the lung. The *BCI* ranges from zero to ten corresponding to sparsely distributed bullae to densely distributed bullae. Four bullae congregation classes are defined based on the *BCI*. The *BCI* is especially useful for comparing the distribution of bullae for cases with approximately the same *PI*, *BI* or *PI* and *BI*.