Quantifying Patterns Of Emphysema By Local Density Histogram In Chest CT Scans

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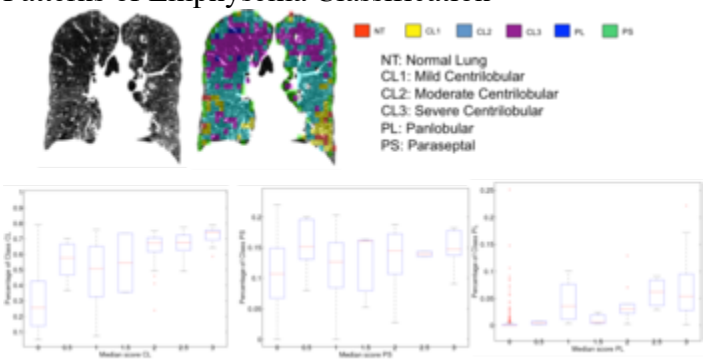
Rationale: A major limitation of global densitometry analysis for emphysema quantification is the lack of specificity for early stage disease and differentiation of patterns related to emphysema pathological types. Local approaches that attempt to classify different patterns of emphysema may better quantify the burden of disease and its progression.

Methods: We have developed a new approach to classify five patterns of emphysema (normal lung tissue, centrilobular (mild, moderate, severe), panlobular and paraseptal). This approach uses the local density histogram as a differentiating feature among tissue classes. The local density histogram is computed over a local region of 31x31 pixels using a kernel density approach. A training set of image patches (31x31 pixels) was first labeled by an expert in 256 subjects from the COPDGene cohort to create a total of 1525 training samples. A kNN classifier was employed to classify new samples that were not included in the training set. The performance of the classifier was analyzed using the leave-one-subject-out technique. After the lung parenchyma is classified, the percentage of each tissue class is reported with respect to the total lung volume. The algorithm was tested on 342 subjects from COPDGene that were visually characterized by a group of expert radiologists and pulmonologists. The median score provided by the expert was compared with the % amount of each tissue class. Relationships between LAA% and the percentages of each emphysema patterns observed were also computed via linear regression analysis.

Results: The classification success rate in the leave-one-subject-out experiment for each emphysema type was: 90.42% for normal lung, 85.37% for paraseptal, 77.03% for panlobular, 37.33% for mild centrilobular, 63.41% for moderate centrilobular and 44.94% for severe centrilobular. 42.4% of the mild centrilobular samples were labeled as normal lung tissue. Figure 1 shows the tissue classification results for a coronal slice (top row) and the agreement between the median score of the readers and the % amount for each tissue class (bottom row). Normal lung tissue and mild centrilobular were negatively associated with LAA% ($r^2=0.69$, $p<0.0001$ and $r^2=0.1121$, $p<0.0001$, respectively). Meanwhile, moderate centrilobular, severe centrilobular, paraseptal and panlobular emphysema were positively associated to LAA% with increasing slope for each emphysema class ($r^2=0.64$, $p<0.0001$, $r^2=0.85$, $p<0.0001$, $r^2=0.45$, $p<0.0001$, $r^2=0.56$, $p<0.0001$, respectively).

Conclusions: Local density histogram is a feasible approach to quantify different types of emphysema in volumetric CT scans. The method is fully automatic and it can be run without supervision with low computational demands

Patterns of Emphysema Classification



Top Row: example of the classification result for one COPDGene subject Botton Row: agreement between the median score of the readers and the percentage amount for each tissue class

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