Automated Airway Scores of Lung CT

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Background and Rationale

- Cystic Fibrosis (CF) is a lung disease that causes increased mortality. Bronchiectasis is a condition, and main characteristic of CF lung disease, in which damaged airways become widened. Airways appear as dark, air-filled, ovoid objects surrounded by a white wall.

- Current technique for determining severity of CF uses the Brody bronchiectasis score. A machine learning approach is reasonable for automatic airway index.
- Automated CT analysis may prove to be beneficial in long term monitoring of patients. A random forest approach can be used to determine severity of CF.

Methods

1. Collect Training Images: Airway and non-airway regions of interest (ROI) were extracted from 20 CF patients and 20 control patients. 48,000 ROIs were collected in total.

2. Feature Vectors: 412 Features were computed on each ROI to convert raw pixel values to more descriptive quantitative values to be used by the classifier.

3. ROI Prediction: By comparing feature vector of each tested ROI to the features of the training set, the RF made a prediction on each ROI as “airway” or “non-airway.”

Software Development

Random Forest Classifier

1. New Chest CT: A 20 x 20 pixel window systematically rolled across each CT slice and grabbed ROIs within the lung tissue. Each red box represents an ROI that would be tested by the RF. This method was performed in both lungs.

2. Feature Vectors: The same feature vectors extracted in the training set of ROIs were computed on each tested ROI.

3. ROI Prediction: RF is an algorithm which decides what category an observation is placed. It is a collection of decision trees that will output a prediction (e.g. “airways” or “non-airways”) based upon the training set.

4. Output: Green crosses display where the program predicted the location of an airway. Colored segments are airways that were previously identified before this project.

Results

AAI vs. Brody Bronchiectasis Scores

- Automated Airway Index (AAI) was calculated for each patient

<table>
<thead>
<tr>
<th>AAI</th>
<th>number of predicted airways</th>
<th>total number of tested ROI</th>
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- AAI = number of predicted airways / total number of tested ROI

- Random Forest Classifier

- Sensitivity: Percentage of correctly identified airways
- Specificity: Percentage of correctly identified non-airways

- Sensitivity: 0.97
- Specificity: 0.98

Discussion

- A machine learning approach is reasonable for automatic airway index.
- Automated CT analysis may prove to be beneficial in long-term clinical trials.
- It would provide a standard and consistent method without the dependency of a reader.
- Automated program may prove to be more sensitive to subtle changes within the lung.

References