Airway Extraction In Inspiratory Volumetric Ct Using Scale-Space Particles

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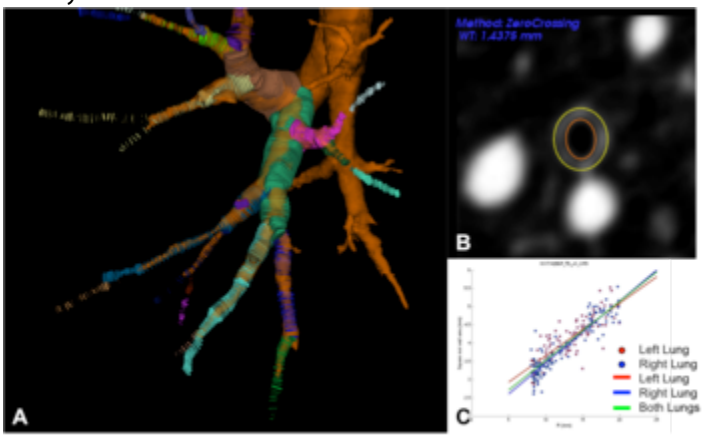
Rationale: A major limitation to large genetic and epidemiologic imaging based studies of COPD is the ability to objectively assess CT measures of airway disease in an efficient fashion. New methods of automated analysis are needed for dependable airway segmentation and analysis.

Methods: We have previously developed a method based on scale-space particles which is an approach that optimally searches for image features using unique characteristics of its second-order derivative. Airways are unique in that the present two large positive second-order derivative when moving from lumen to airway wall and a small derivatives along the longitudinal axis. After initially placing the particles in given scale locations within low attenuation structures adjacent to the pulmonary vasculature, their placement is refined in two steps. First, a constraint step moves the particles to locations of minimal local intensity along the direction of the largest variation of the second order derivative (centering the particle within the airway lumen). Second, particles interact with each other in both the spatial and scale dimensions to minimize a global energy. This latter step ensures homogenous sampling along the length of the airway. A final filtering step removes outlier particles that were placed in airway-looking locations in the parenchymal field. The CT is then reformatted orthogonal to the airway axis at each remaining particle location and the wall thickness was measured using phase congruency for 30 rays cast from the particle point. One thousand six hundred seventy one inspiratory CT scans from the COPDGene study were analyzed. For each subject, Pi10 was computed and univariate and multivariate linear regression were used to show the association with FEV1%.

Results: The cohort consisted of 870 males and 801 females with a mean age of 61±9 years and a mean tobacco smoke exposure of 46±26 pack-years. The mean FEV1%predicted of the cohort was 73.5%±26.8. Pi10 measured by scale-space particles is associated to FEV1% (r^2 =-0.19, p<0.0001). In a multivariate model adjusted for the percent emphysema (%LAA-950HU), and percent gas trapping (%LAA-856HU on the expiratory CT scans), Pi10 remained a significant predictor of the FEV1% predicted (P<0.0001) (model r^2=0.62).

Conclusions: Scale-space particles is a feasible approach to efficiently sample airway locations in volumetric CT scans. The method is totally automatic and it can be run without supervision. Although, scale space particles does not provide topological information about the airway tree, further processing can be applied to link nearby particles and extract this information

Airway Extraction Process



(A) Scale-space particles result shown with the bronchial tree extracted by region growing. (B) Airway wall detected at a particle location. (C) Pi versus square root of wall area scattered plot for a subject and the regression lines to compute Pi10 .

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