Predicting Pulmonary Function Abnormalities with a Texture-Based Quantification of Normal Lung Parenchyma in Chest Computed Tomography

Introduction

- Quantitative computed tomography (QCT) techniques might provide objective quantification with some advantages to the visual assessment of abnormal lung parenchyma attenuations.

- We aim to predict pulmonary function abnormalities (restrictive and/or obstructive patterns) with the texture-based convolutional neural networks (CNN) quantification of normal lung index (NLI) on conventional and low-dosage chest CT images.

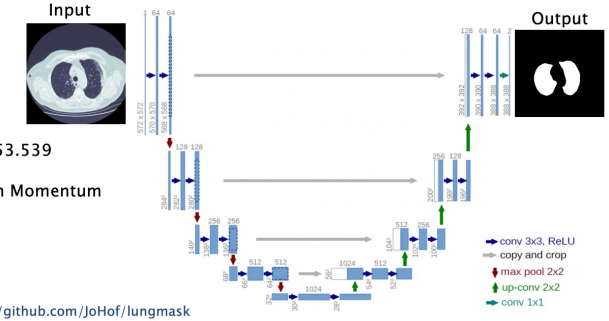
Methods

- Two CNNs were trained for automatic lung segmentation and classification of low- (LAAs; emphysema, cysts), normal- (NAAs; normal parenchyma), and high-attenuation areas (HAAs; ground-glass opacities, crazy paving/linear opacity, consolidation). NLI was calculated as $NLI = 100^{x}[NAA/(LAA + NAA + HAA)]$.

Classification

Segmentation

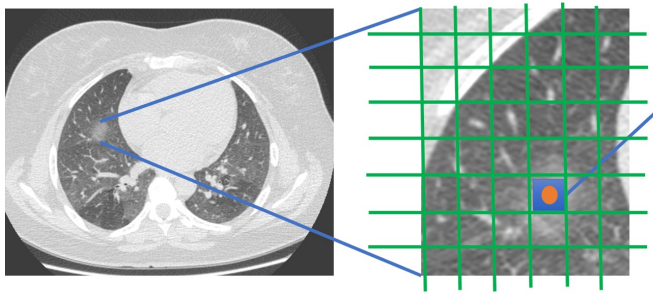
U-Net R231

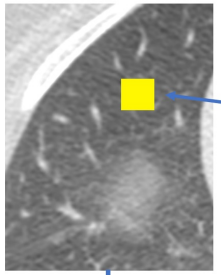


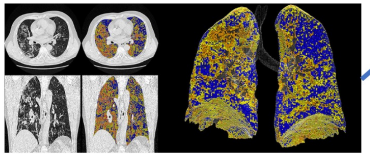
Parameters = 28.953.539

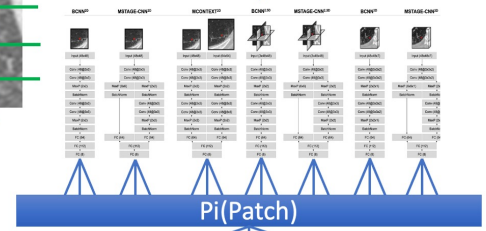
Optimizer = SGD with Momentum

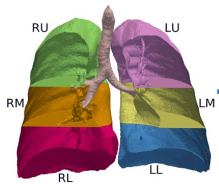
Model available in: https://github.com/JoHof/lungmask

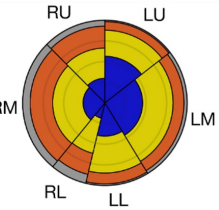


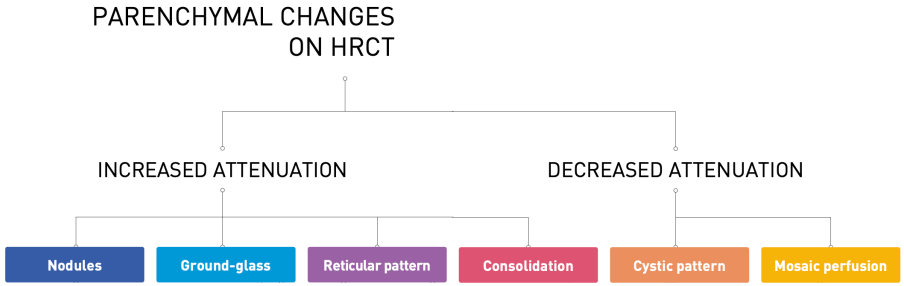




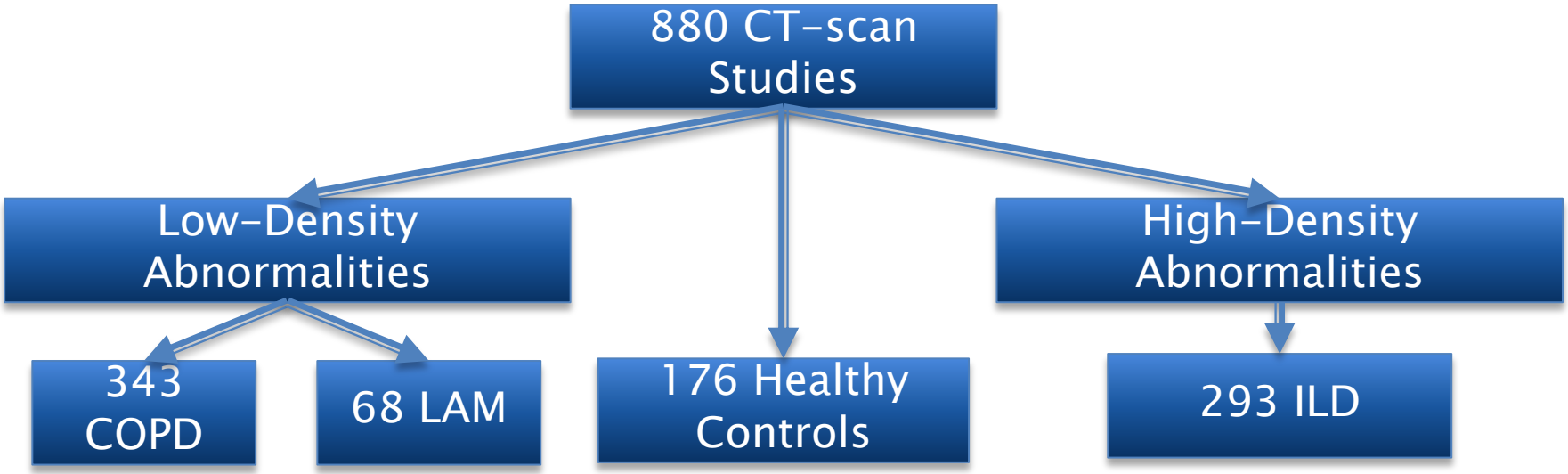








- We assessed **880 conventional CT scans** from **176 normal subjects**, **343 patients with emphysema**, **68 with lymphangioleiomyomatosis** (LAM) and **293 patients with interstitial lung disease (ILD)**.
- A Receiver Operating Characteristic (ROC) analysis was used to assess the performance of NLI to distinguish controls from emphysema, LAM and ILD patients with abnormal pulmonary function tests (PFTs).
- The criteria used to define normal spirometry findings were a prebronchodilator FEV_1/FVC greater than or equal to 70% and FVC% and FEV1% values greater than or equal to 80%.



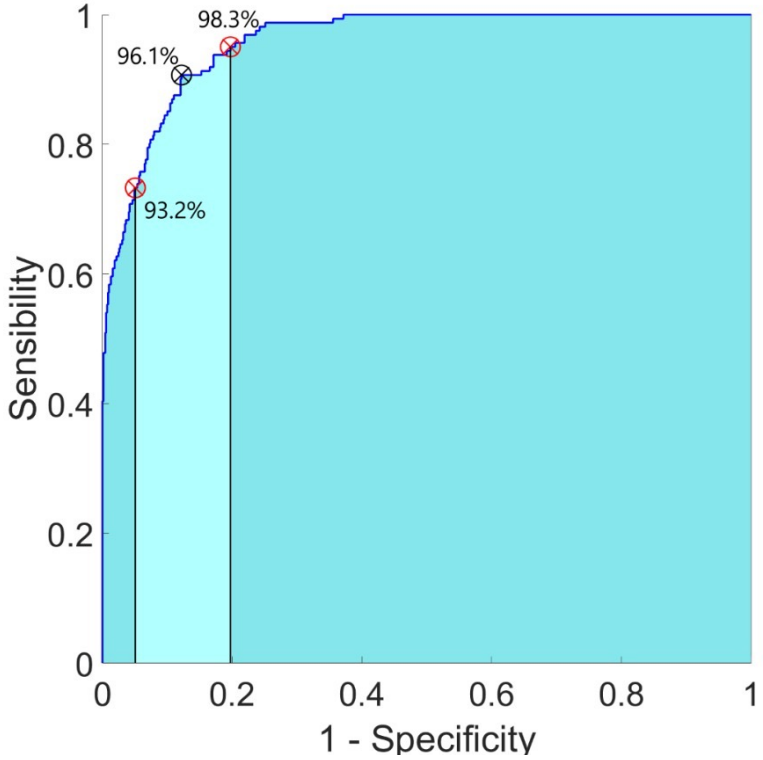
Results

Out of 880 subjects, **161 controls**, **86** patients with **emphysema**, **34 LAM** and **77 ILD** subjects were classified as having normal PFTs.
NLI 5, 50 and 95% percentiles in healthy control subjects were **93.1, 99.6 and 99.9%,** respectively.

A reference equation for NLI was also generated:

NLI (mL) = 842*Sex (1 = male, 0 = female) + 4164 * Height (m) – 2451

(R^2 = 0.55, adjusted R^2 = 0.55, F-statistic = 101 and P < 0.0001). NLI expressed as a percentage of predicted values decreased with disease severity.



ROC CURVE PARAMETERS

- Distance:	0.1534
- Threshold:	96.1073
- Sensitivity:	0.9068
- Specificity:	0.8781
- AROC:	0.9587
- Accuracy:	0.8835
- PPV:	0.6348
- NPV:	0.9758
- FNR:	0.0932
- FPR:	0.1219
- FDR:	0.3652
- FOR:	0.0242
- F1 score:	0.7468
- MCC:	0.6923
- BM:	0.7849
- MK:	0.6106

Conclusions

This study reported reference values, thresholds, and reference equations for NLI derived from quantitative CT scans assessments of subjects with normal lung function and CT findings. NLI estimations might aid in the screening of patients with lung parenchymal abnormalities.