Enhancing Pulmonary Involvement Assessment in Computed Tomography Scans Using Predictive Models Based on Demographics and Anatomical Measurements

Introduction

- This study focuses on enhancing the assessment of pulmonary involvement in computed tomography (CT) scans, commonly referred as the volume of abnormal lung opacities adjusted to CT-computed lung volume (CT_{LV}). However, lung diseases modify lung parenchyma structure, affecting total lung capacity and CT_{LV}, thereby necessitating improved accuracy in measuring lung involvement.

- We propose a methodology to calculate predicted CTLV (pCT_{LV}) using demographic factors (sex, age, body weight, height) and anatomical measurements (maximum lengths of clavicle, scapula, sternum) derived from chest CT scans. This is particularly useful as patient height is often not recorded in routine CT studies.

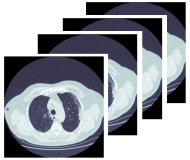
Methods

- We employed a U-Net Convolutional Neural Network (CNN) for automatic lung segmentation from 173 CT scans of healthy individuals.

$$CT_{LV} = \text{pixel size}^2 \times \text{slice thickness} \times \text{total number of pixels}.$$

Segmentation

Input



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Total Segmentator

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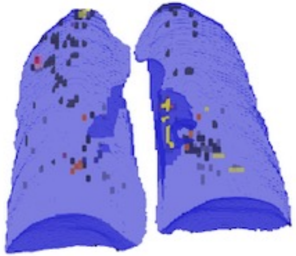
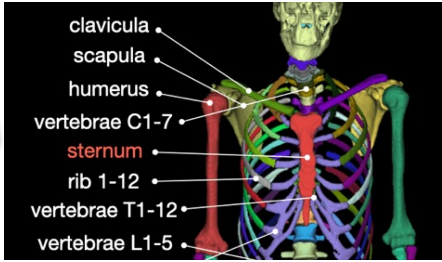
Post Processing

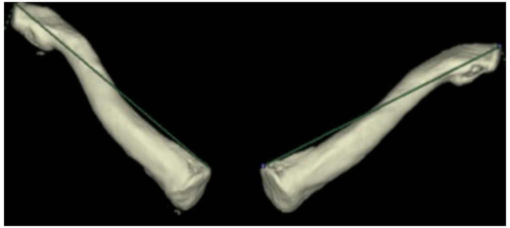
Output

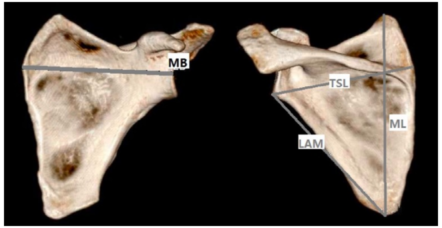




$$CT_{LV} = \textbf{pixel size}^2 \times \textbf{slice thickness} \times \textbf{total number of pixels}.$$

Right and left claviculae, scapulae and the sternum were automatically segmented, and their maximal length were computed.

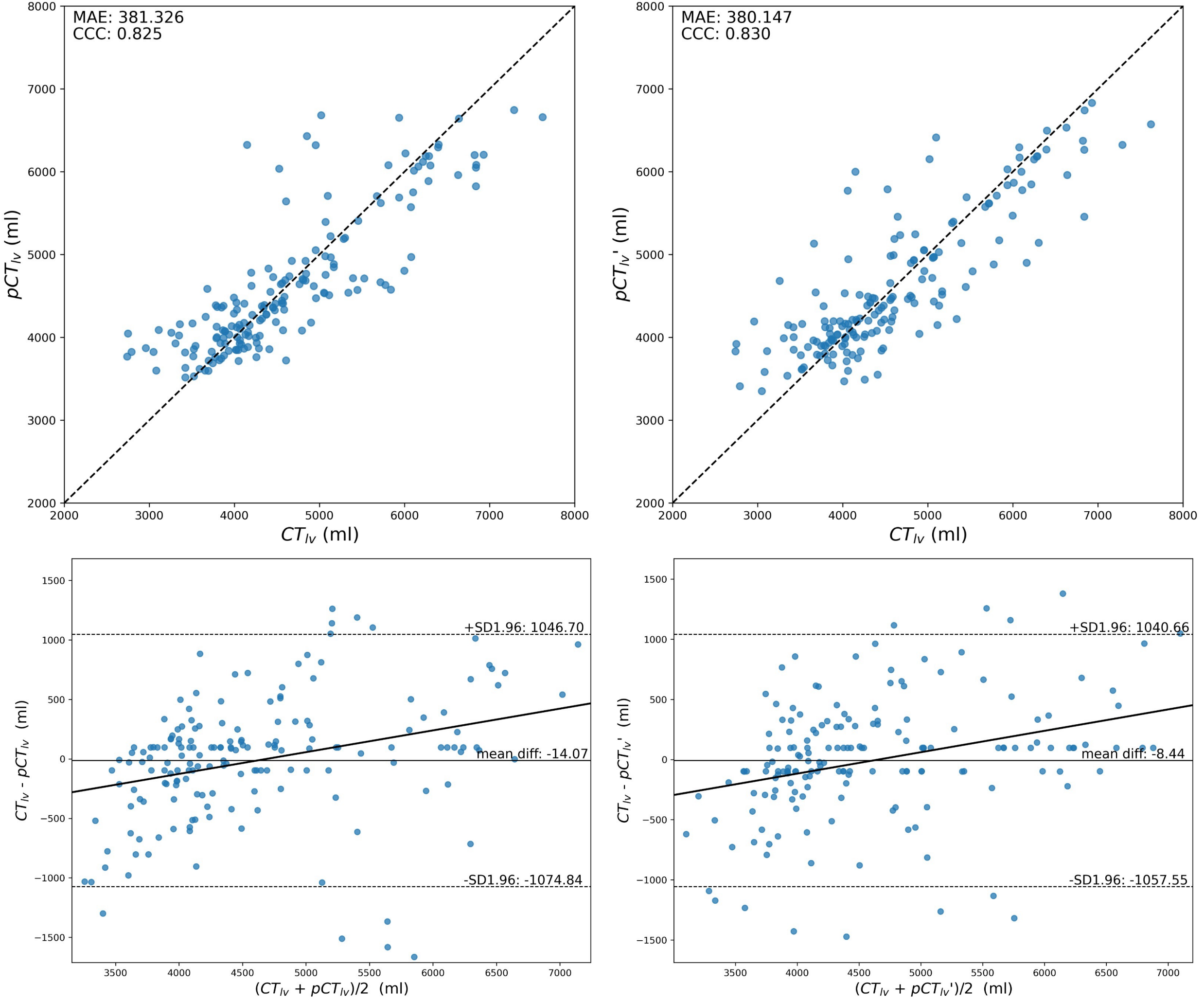




- A **Support Vector Regression** (SVR) model was developed using body height, weight, sex, and age to estimate pCT_{LV}. An alternative pCT_{LV} model (pCT_{LV}') was also formulated, substituting body height with the maximal lengths of clavicles, scapulae, and sternum. The dataset was randomly split into 70% training and 30% testing, and we assessed various hyperparameter ranges for the SVR model with the "Radial Basis Function" kernel. The model's accuracy was evaluated using a Bland-Altman plot.

Results

- The pCT_{LV} model demonstrated a mean absolute error of 334.2 ml in training, **470.0 ml in testing**, and a global error of 385.5 ml (R^2 Training = 0.71, **Test = 0.63**, **Global = 0.68**).
- The pCT_{LV}' model showed a mean absolute error of 341.2 ml in training, **508.7 ml in testing**, and a global error of 380.1 ml (R2 Training = 0.74, Test = 0.60, **Global = 0.71**).
- We observed a 14.1 ml and -8.4 ml specific bias between CT_{LV}, pCT_{LV}, and pCT_{LV}', respectively and this bias increased with CT_{LV}.



Conclusions

The study introduces two equations for assessing pCT_{LV} in chest CT scans, applicable with or without body height data. These models exhibit comparable performance and could potentially increase the accuracy in determining the extent of pulmonary involvement in lung diseases.