HSLU Hochschule Luzern

Technik & Architektur

Bachelor Thesis Medizintechnik

Pneumothorax-Segmentation and Volumetrics in computed tomography (CT) scans

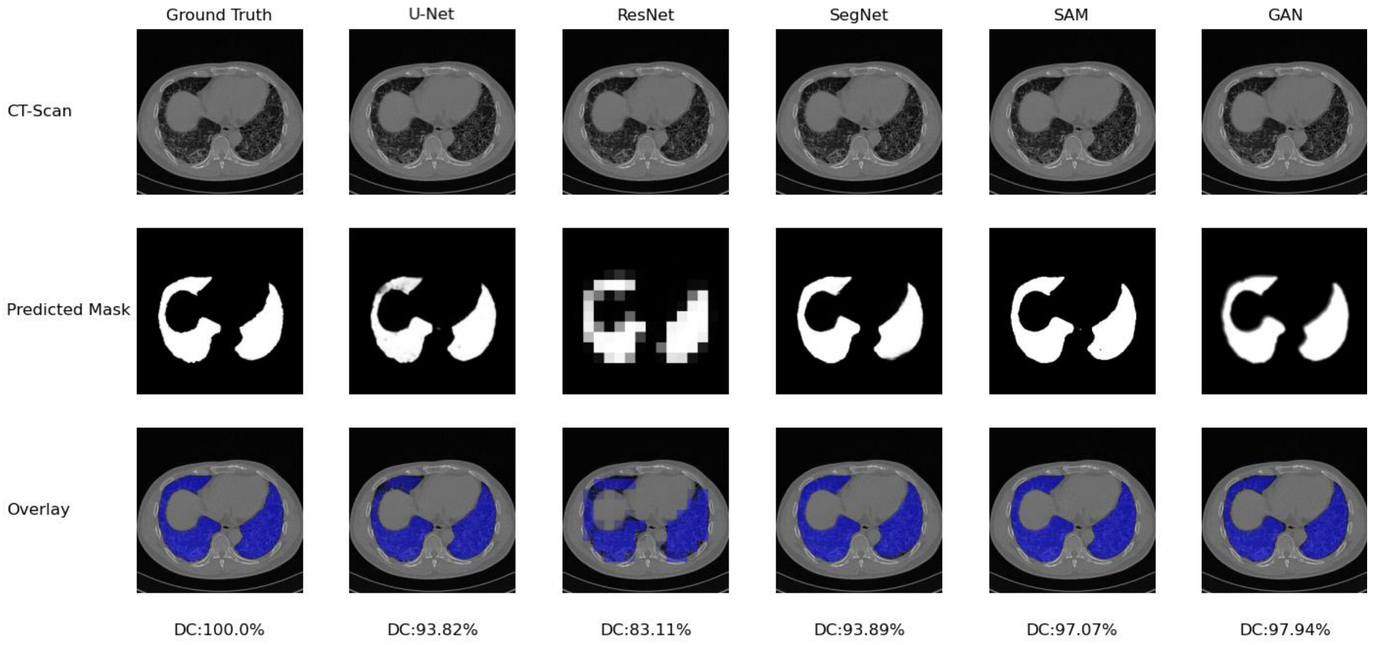

Figure 1: Performance of lung segmentation on a selected image of the openly available dataset.

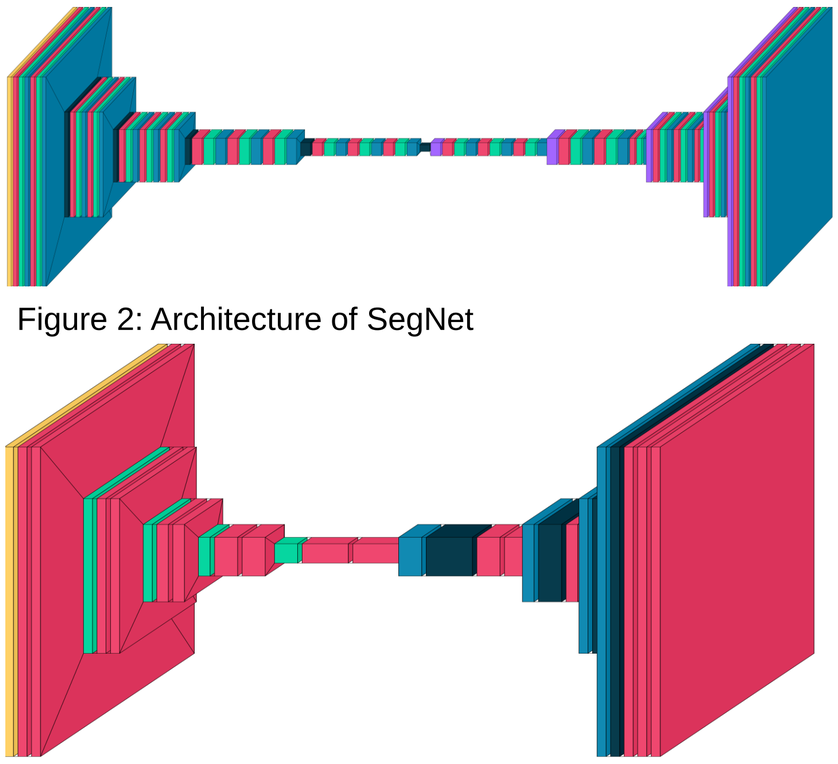

Figure 2: Architecture of SegNet

Figure 3: Architecture of U-Net

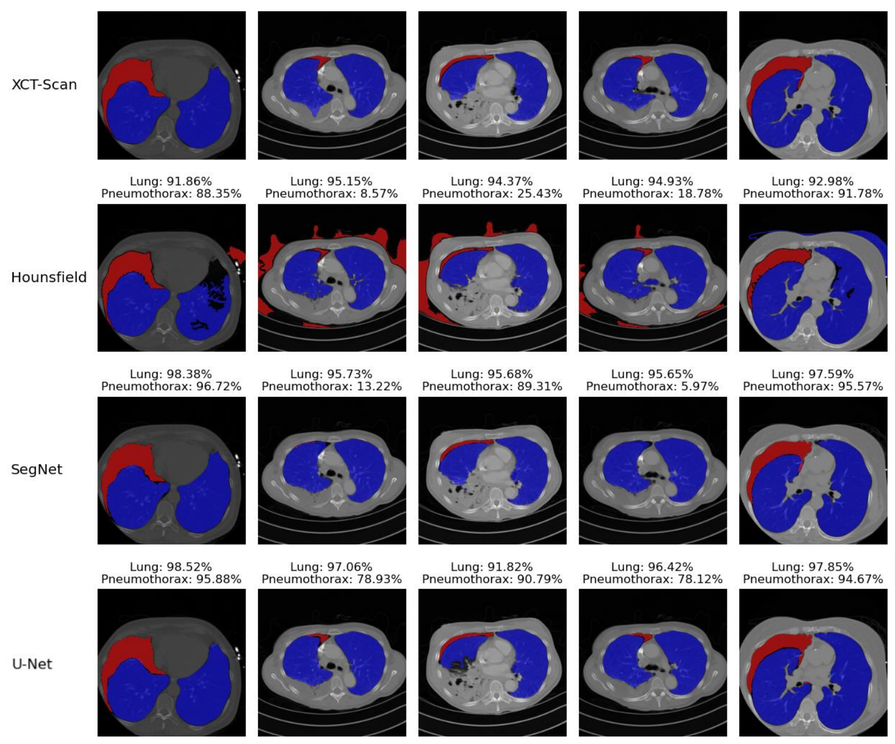

Figure 4: Segmentation examples on data provided by UHL

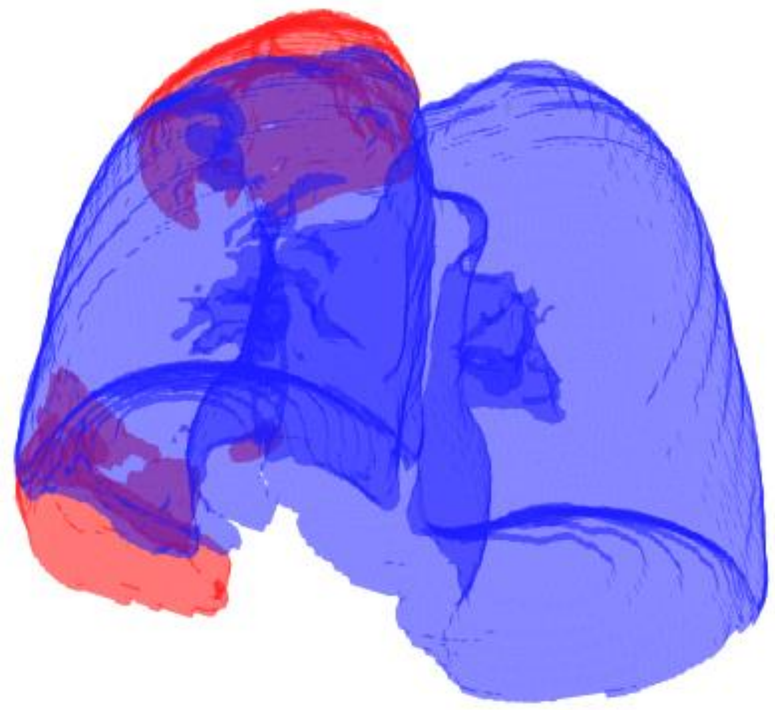

Figure 5: Visualisation of segmented pneumothorax and lung

Problem definition

A pneumothorax describes the accumulation of air or gas in the space between the lung and the chest wall. For diagnostic purposes computed tomography (CT) scans are performed.

To determine the severity of a pneumothorax and then to derive the proper treatment for it, the size of the pneumothorax has to be determined. Currently, radiologists only approximate this by measuring the distance between the edge of the lung and the peripheral pleura at multiple points.

This bachelor thesis focuses on the development and evaluation of various segmentation techniques for the automatic identification and volumetric quantification of pneumothoraces in CT scans of the thorax. A major goal of this thesis is to compare neural networks to traditional segmentation algorithms to determine the most promising approach.

Solution Concept

Five different Convolutional Neural Networks (CNNs) are evaluated for their lung segmentation capabilities on a public available dataset.

The best-performing CNN is optimised to segment pneumothoraces on the data provided by the university Hospital Lucerne (UHL). The optimised model is then used to quantify pneumothoraces on a full thoracial CT scan from UHL.

Results

An example of the different segmentation performances is shown in Figure 1. The numbers below the images provide the achieved Dice Coefficient for the shown image. The best results on a test set were achieved by SegNet (Figure 2) with an average Dice Coefficient of 61.63% followed by U-net (Figure 3) with 59.38%.

Both models were optimised and retrained to segment pneumothoraces using the dataset provided by UHL. Figure 4 displays the segmentation results on five different images from the UHL dataset. The first row has the annotated ground truth overlaid. Achieved Dice Coefficients are displayed above each image. The best performance was achieved by an optimised U-Net model with a Dice Coefficient of 89.63%.

Figure 5 illustrates a volumetric quantification achieved using the optimised U-Net model. It shows a pneumothorax that occupies 4.35% of the thorax, and 9% of the affected hemithorax. On a statistically non-significant case study, a deviation from an annotaded quantification of only 4.23% was achieved.

Overall, this thesis contributes a robust methodology for pneumothorax quantification in CT scans, offering potential clinical application after further validation and refinement.

Pascal Tschümperlin

Supervisor:
Prof. Dr. Philipp Schütz

Expert:
Dr. Iwan Jerjen

Industry Partner:
university Hospital Lucerne
Prof. Dr. med. Justus E. Roos
Dr. med. Thomas Treumann
PD Dr. med. Tobias Gassenmaier

FH Zentralschweiz

luzerner kantonsspital