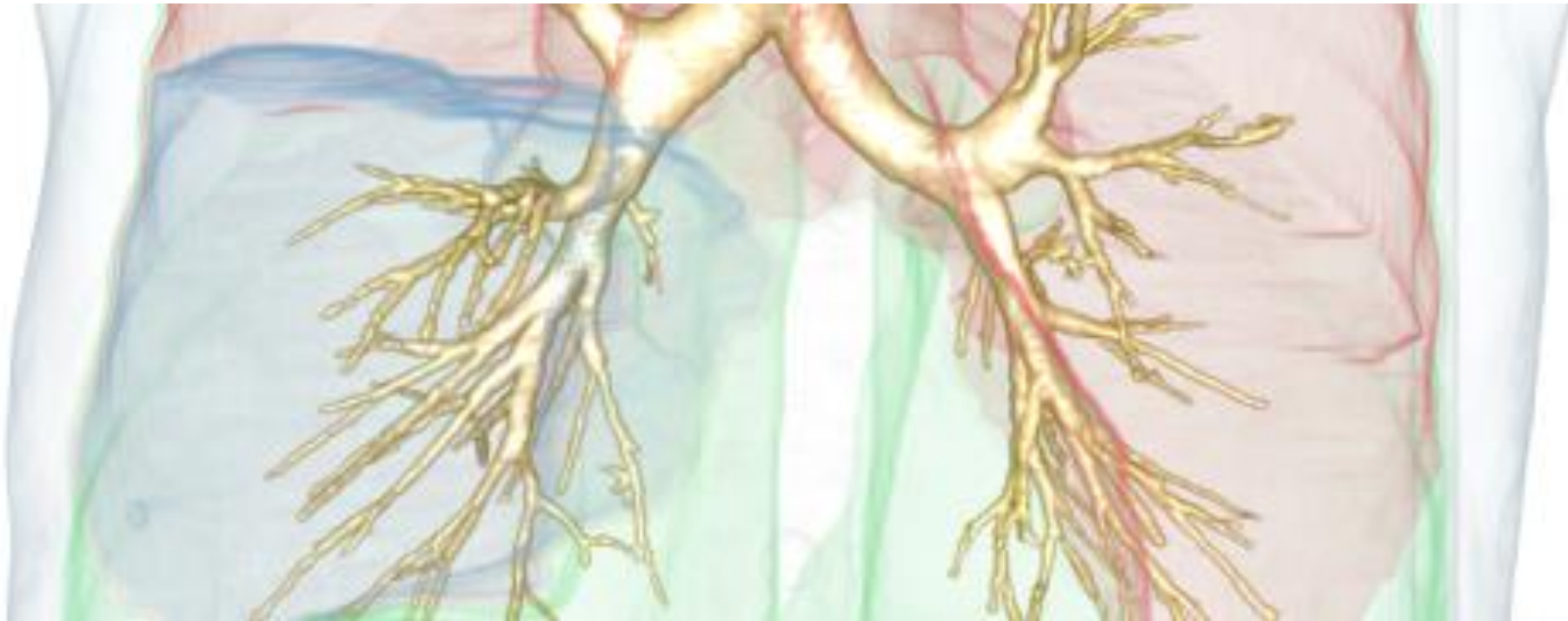# AUTOMATIC SEGMENTATION OF THE PULMONARY LOBES WITH A 3D U-NET AND OPTIMIZED LOSS FUNCTION
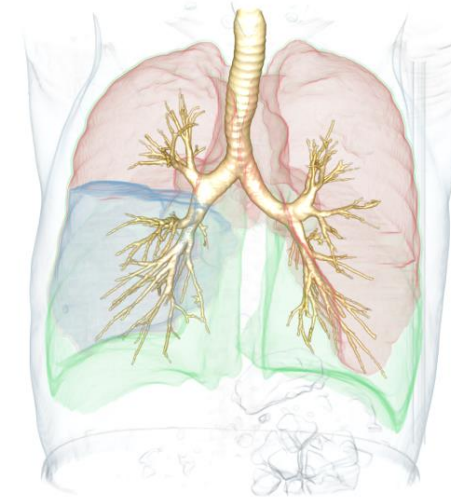
Bianca Lassen-Schmidt, Alessa Hering, Stefan Krass, Hans Meine
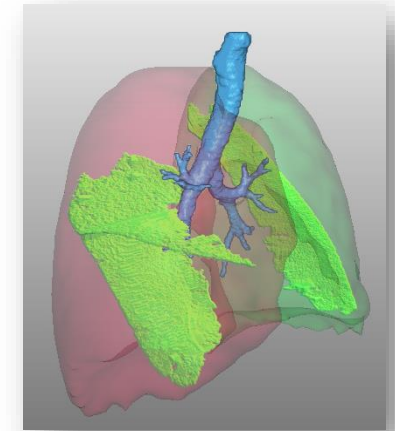
MIDL
Montréal 2020

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MEVIS

Motivation

Rendering of
pulmonary lobes

Rendering of pulmonary
fissures (green)

- **Lungs** can be subdivided into **five lobes** with separated supply branches for both vessels and airways

- **Accurate segmentation** of the pulmonary lobes is important for **diagnosis, treatment planning and monitoring**

- There are **fissures between the lobes** that can be incomplete or even missing

- Previous work:

  - **Watershed-based** segmentation **integrating fissures** *

  - **3D u-net segmentation** without weighting

- Challenge

  - **Improve 3D segmentation u-net at lobar boundaries**
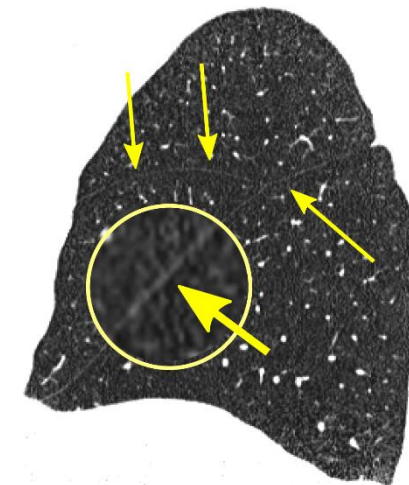

Fissures in sagittal view

* B. Lassen et al.: Automatic segmentation of the pulmonary lobes from chest CT scans based on Fissures, Vessels, and Bronchi. IEEE Transactions on Medical Imaging, 32(2):210-222, 2013

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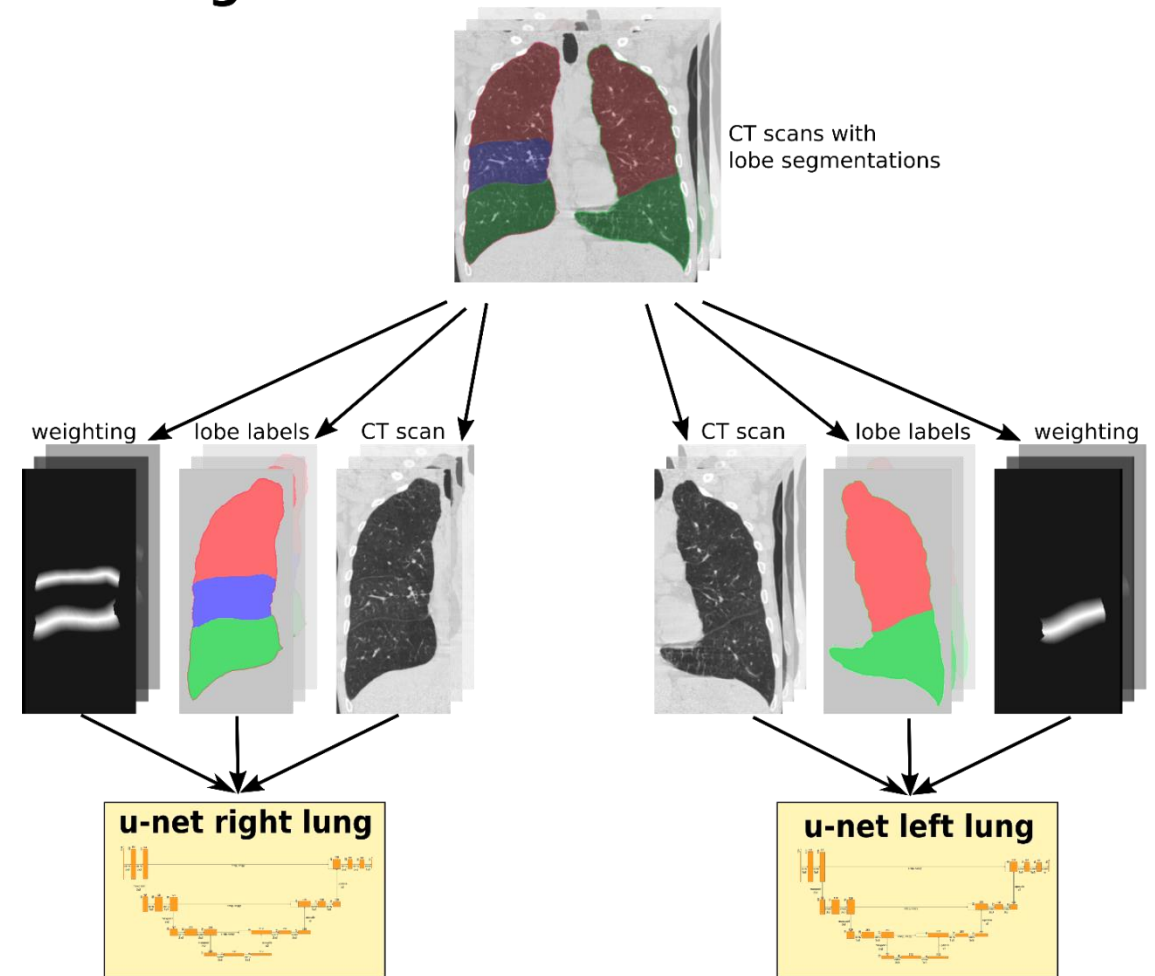MEVIS

Method

- **3D u-net for lobe segmentation** with **weighted Dice loss**

- **Weighting gradient image**: value 10 at the lobar boundaries descending to value 1 within 10 mm radius

- Separated u-nets for left and right lung

- 4 resolution levels, filter size 3^3 for the convolutions, resampled: 1.5 mm³, patch size: 60^3 voxels, padding: 44 voxels, learning rate: 0.005, PReLu activation, batch normalization, dropout

- Data*: **70 lung CT scans** (49 training, 7 validation and 14 testing)

CT scans with lobe segmentations

weighting   lobe labels   CT scan

CT scan   lobe labels   weighting

**u-net right lung**

u-net left lung

* Data and references from: H. Tang et al.: Automatic pulmonary lobe segmentation using deep learning. CoRR, abs/1903.09879, 2019. and
B. Lassen et al.: Automatic segmentation of the pulmonary lobes from chest CT scans based on Fissures, Vessels, and Bronchi. IEEE Transactions on Medical Imaging, 32(2):210-222, 2013
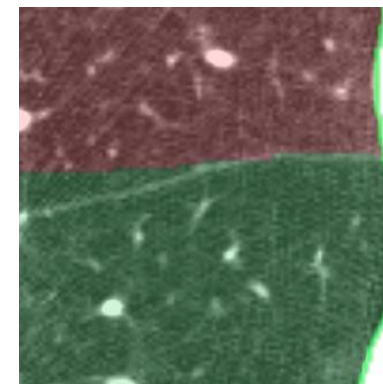
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Results

- Comparison to

  1. **watershed method**

  2. **u-net without weighting**

- Metric: **Mean distance** from visual fissure

- Segmentation time < 6 seconds

Original CT

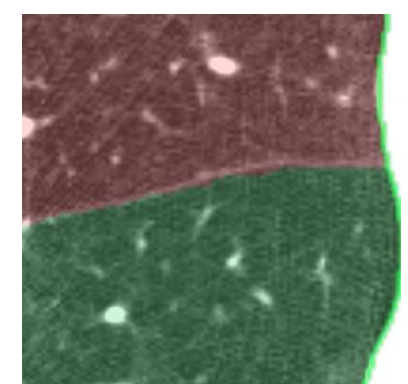Average Surface Distance — AutoMethod, without Weighting, with Weighting
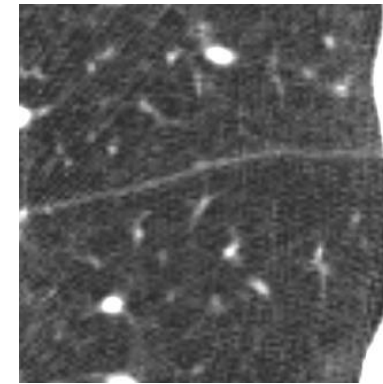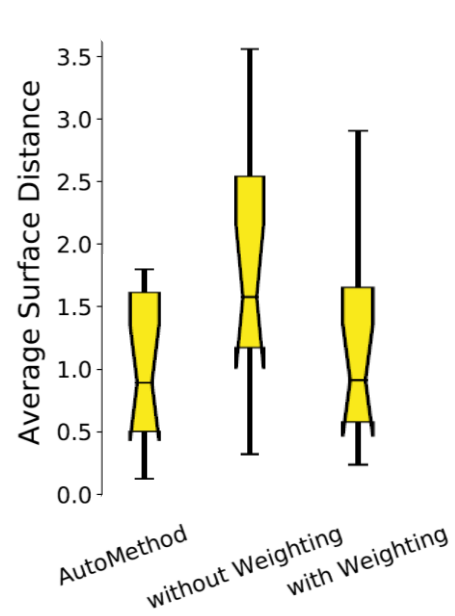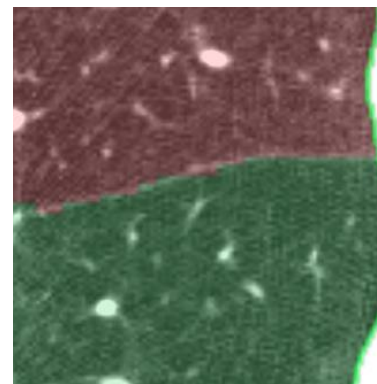
Watershed

U-net without weighting

U-net with weighting

Summary & Outlook

- Summary:

  - First 3D u-net for lobe segmentation with **fissure information as weighted loss**

  - Emphasizing the lobar boundaries in the loss function **improved the segmentation results**

- Future work:

  - Training and evaluation on a **larger database including a wide range of pathologies**

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