Lehrstuhl für Bildverarbeitung
Institute of Imaging & Computer Vision

3D Surface-Based Detection of Pleural Thickenings

P. Faltin[1], K. Chaisaowong[1,2]

[1]Institute of Imaging & Computer Vision, RWTH Aachen University, 52056 Aachen, Germany
[2]King Mongkut's University of Technology North Bangkok, 10800 Bangkok, Thailand

Medical Background

Long-term consequences of asbestos exposure

- Commonly used till the 1990s (in Germany)
- Accumulated in the lung
- Permanent penetration of pleura
  - ⇒ Thickenings and pleuramesothelioma
  - ⇒ Long latency of 14-72 years
- Expected maximum of diagnosed cases 2018 [1]

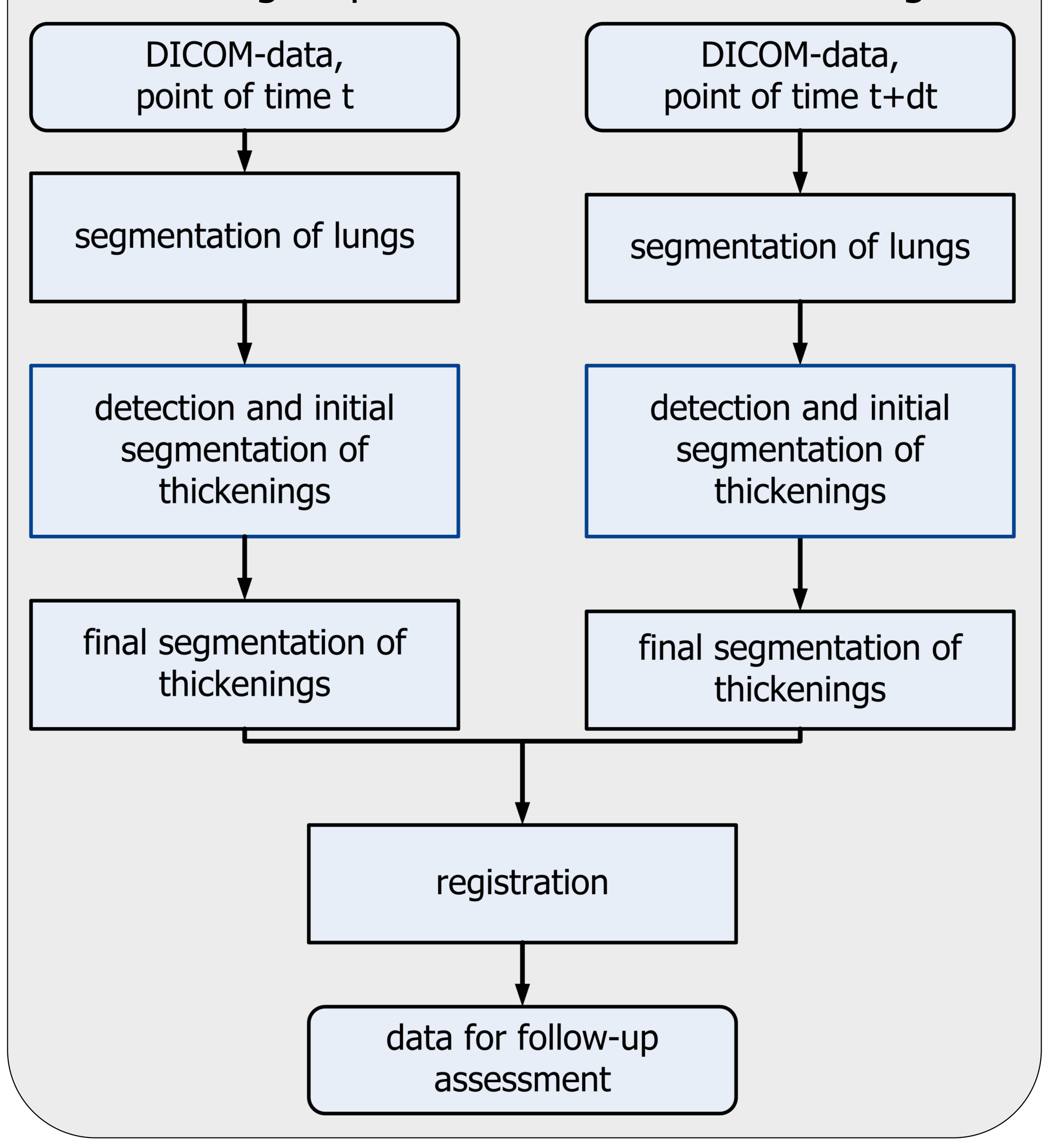
Motivation

Difficulties in diagnosis

- High workload (each datasets with 700 slices)
- Strong inter- and intra-reader variance [2]
- Manual volumetric measurements not practicable
- Follow-up assessment by matching thickenings
- To date, thickening expansion in transverse-direction only partially regarded

Framework

- Fully automatic processing
- Detected thickenings and matching modifiable
- Follow-up assessment with objective volumetric measurements
- Processing steps realized in 3D volume image



Methods

- Healthy lung modeled individually
- Potential thickenings described by difference of healthy and actual lung
- Required input data: lung mask, obtained by two-step supervised thresholding [3]
- Provided output data: pre-segmented thickenings

Sliding Convex Hull

- Definition:

$$conv(\boldsymbol{R_z}) = \left\{ \sum_{i \in \boldsymbol{R_z}} a_i \, \boldsymbol{i} : \sum_{i \in \boldsymbol{R_z}} a_i = 1;\ a_i \geq 0 \right\}$$

- For each slice z:

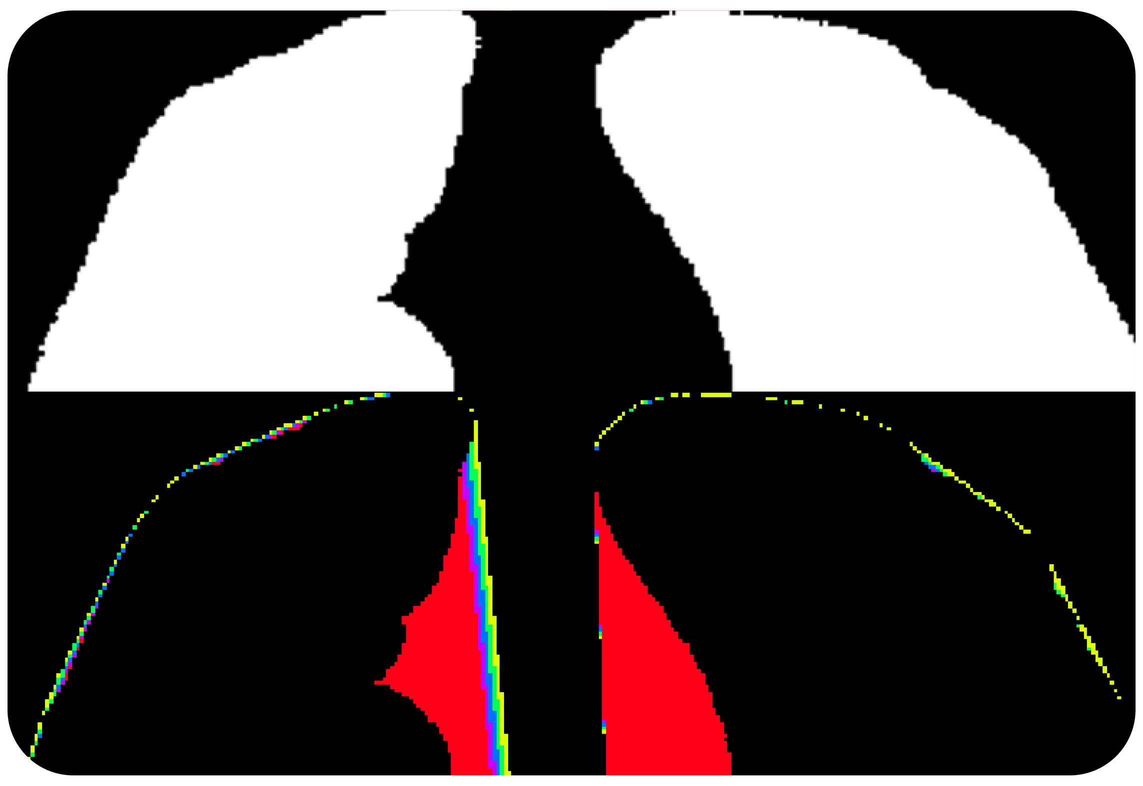
$$\boldsymbol{R_z} = \{(x, y, \hat{z}) \in \boldsymbol{R} :\ |z - \hat{z}| \leq n\}$$

Thickening Segmentation

- Thickenings are small (<2000 mm³) compared to expected healthy anatomical structures (>10000 mm³)
- Thickening tissue has higher CT-number (20 to 60 HU) compared to fat tissue (-220 to -50 HU)

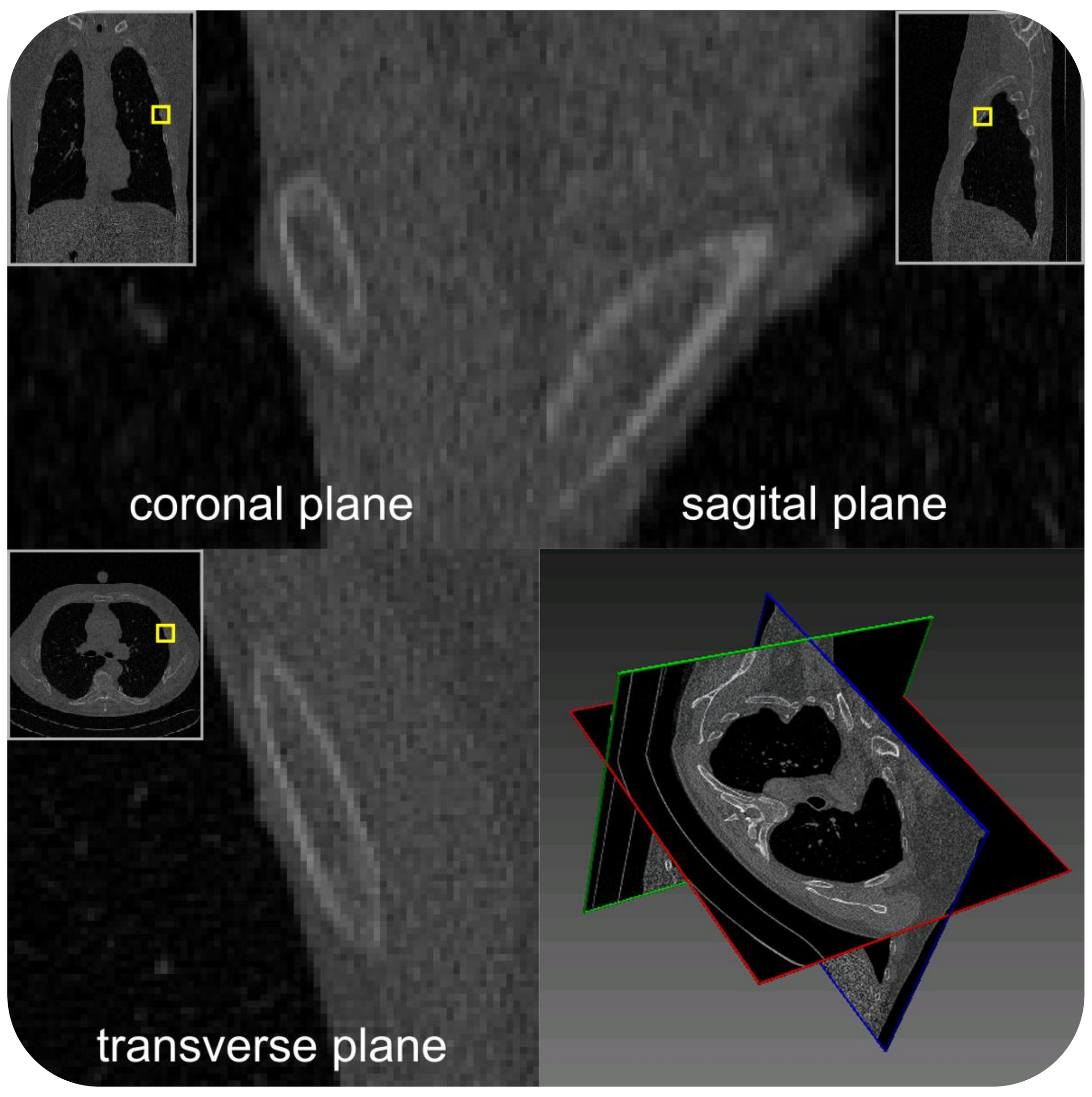
Exclude Healthy Structures

- Macroscopic anatomic structures might cover thickenings
- Structures masked by erosion
- Growing structuring element
- Combination of results from all erosion levels provides final set of thickenings

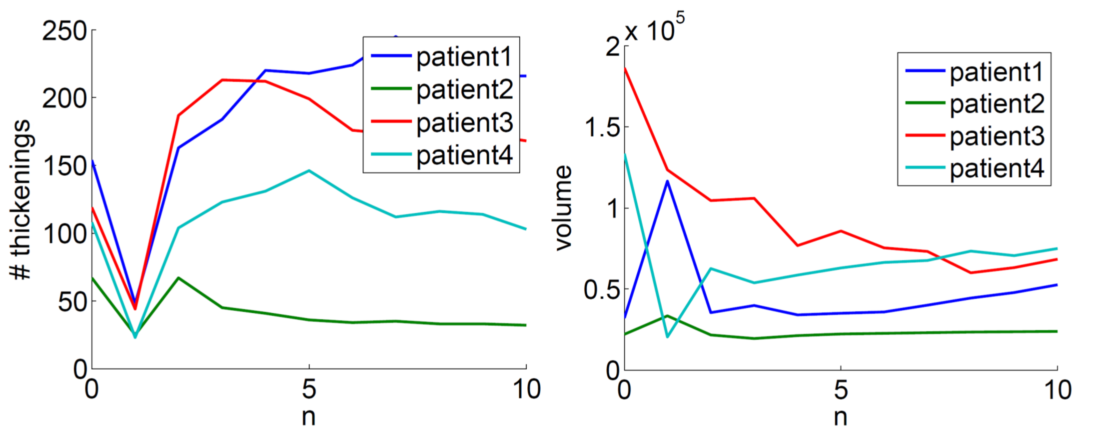


Notes on the Implementation

- Number of points reduced by edge detection
- Convex hull created by Quickhull algorithm [4]
- Fast voxelisation of triangles by extracting slice crossing triangles



Results & Conclusion



- Number and volume of thickenings are compared
- Stable results for parameter $n \geq 4$

⇒ Successful consideration of connectivity in z-direction by adapted expansion of hull

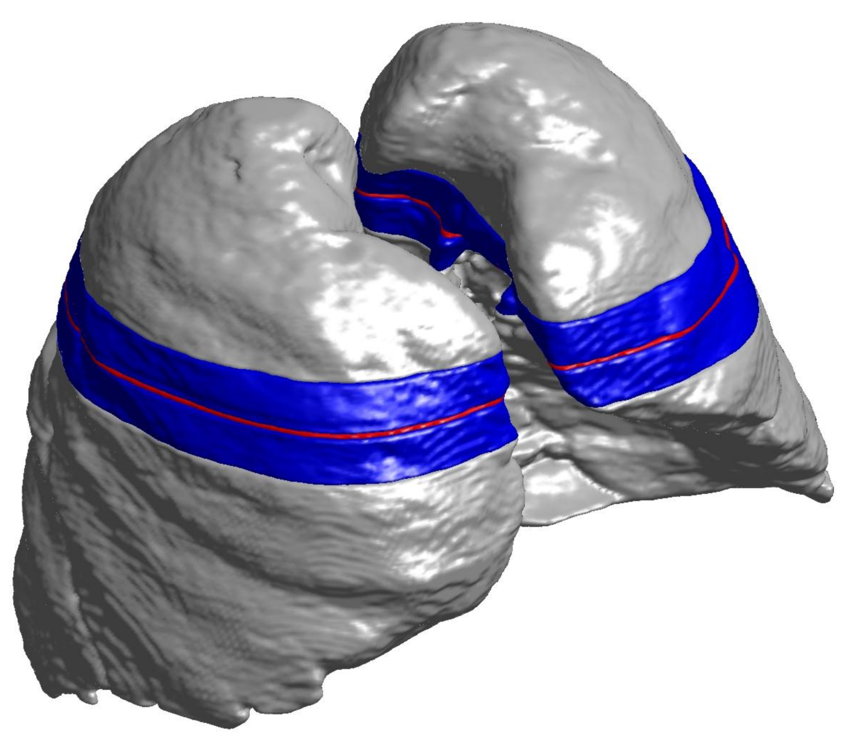
References

[1] M. Pistolesi, J. Rusthoven. Malignant Pleural Mesothelioma: Update, Current Management, and Newer Therapeutic Strategies. Chest, 2004, vol. 126, no. 4, pp. 1318–1329.

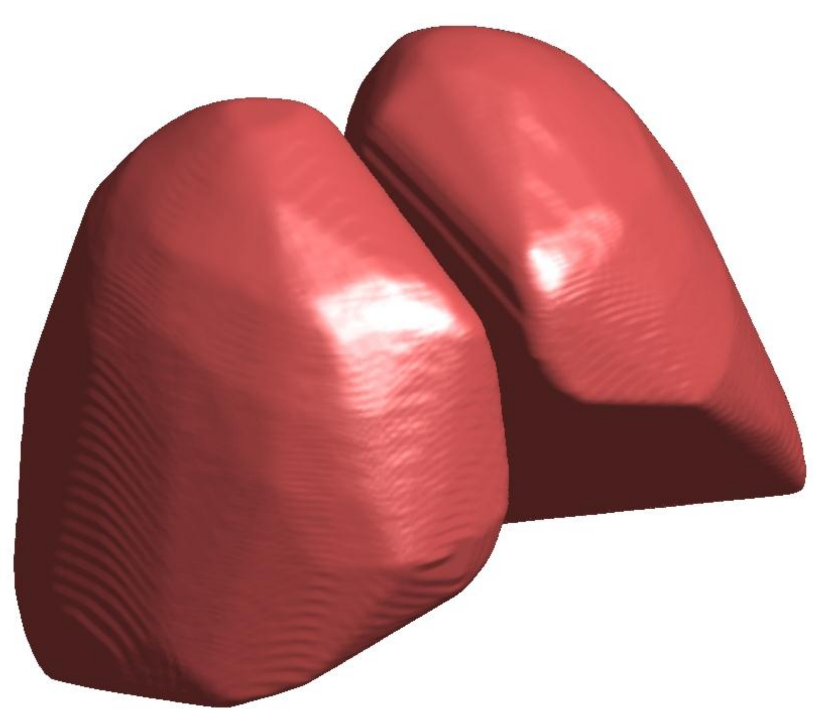
[2] T. M. I. Carl. Interreadervarianz bei der HRCT- und CXR-Befundung in einer Längsschnittstudie bei Ehemals Asbeststaubexponierten Personen. Ph.D. thesis, Medizinische Fakultät, RWTH Aachen, 2004.

[3] K. Chaisaowong, B. Bross, A. Knepper, T. Kraus, T. Aach. Detection and Follow-up Assessment of Pleural Thickenings from 3D CT Data. ECTI-CON, 2008, vol. I, pp. 489 – 492.

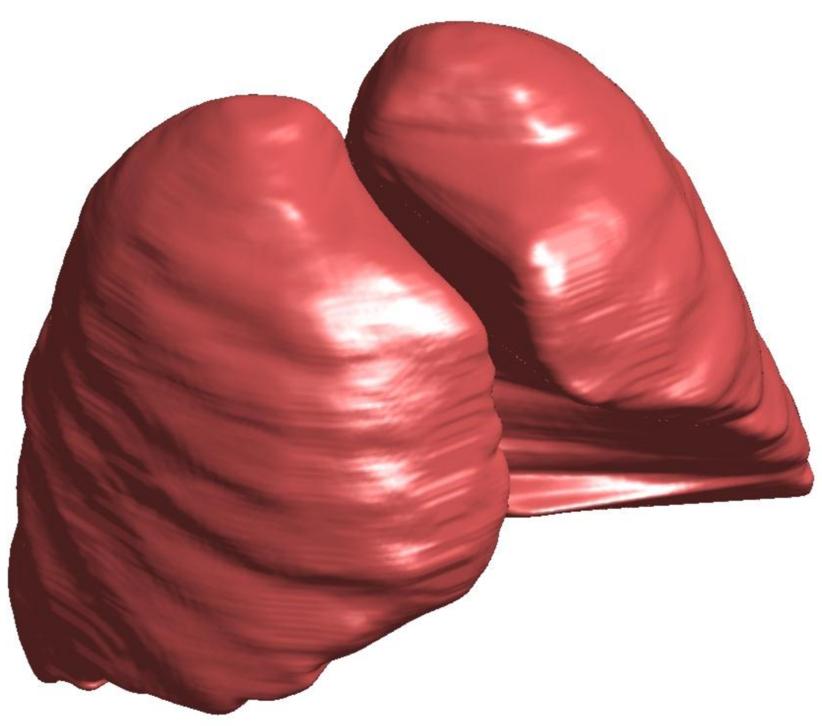
[4] C. Bradford Barber, D. P. Dobkin, H. Huhdanpaa. The Quickhull Algorithm for Convex Hulls. ACM Transactions on Mathematical Software, 1996, vol. 22, no. 4, pp. 469–483.



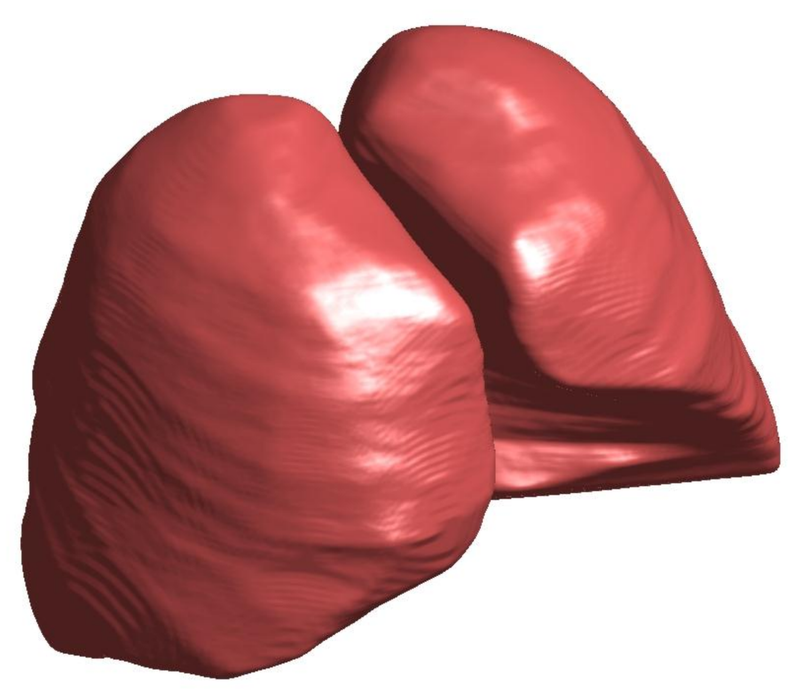
sliding convex hull principle



$n = Z$ (3D convex hull)



$n = 0$ (2D convex hull, transverse plane)



n =20

RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN

Institute of Imaging & Computer Vision, RWTH Aachen University
Prof. Dr.-Ing. Til Aach, Sommerfeldstr. 24, D-52074 Aachen
http://www.lfb.rwth-aachen.de, lfb@lfb.rwth-aachen.de