W I S S E N ▪ T E C H N I K ▪ L E I D E N S C H A F T

Medical Image Analysis (MIA)

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KU Sheet 2

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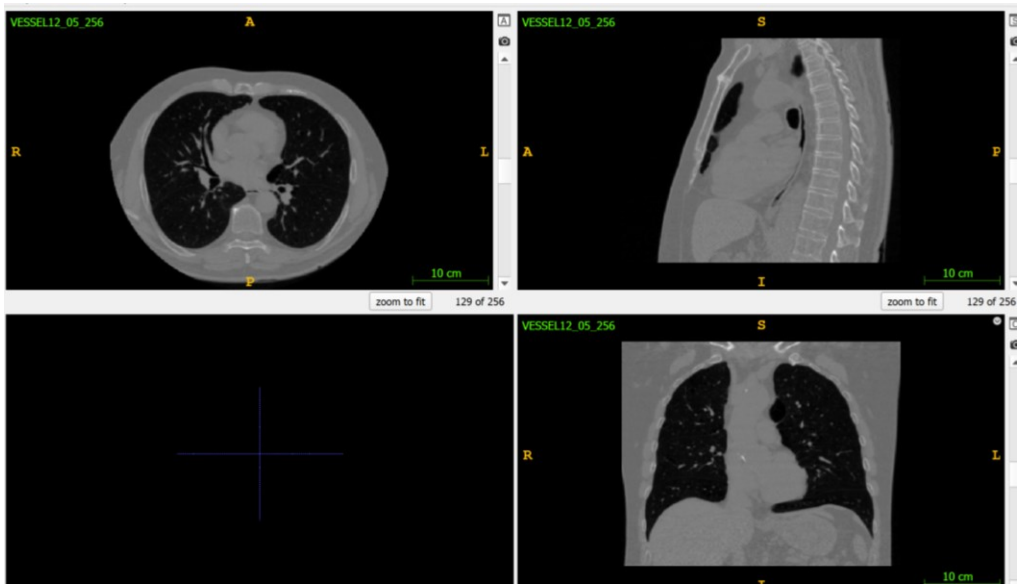
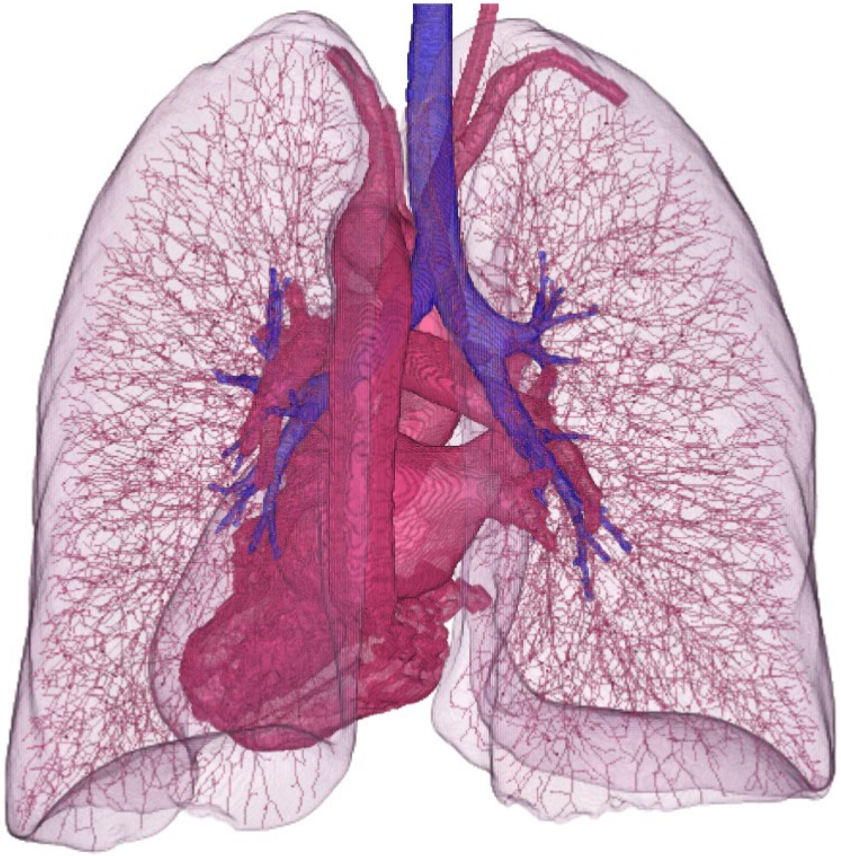
KU Exercise

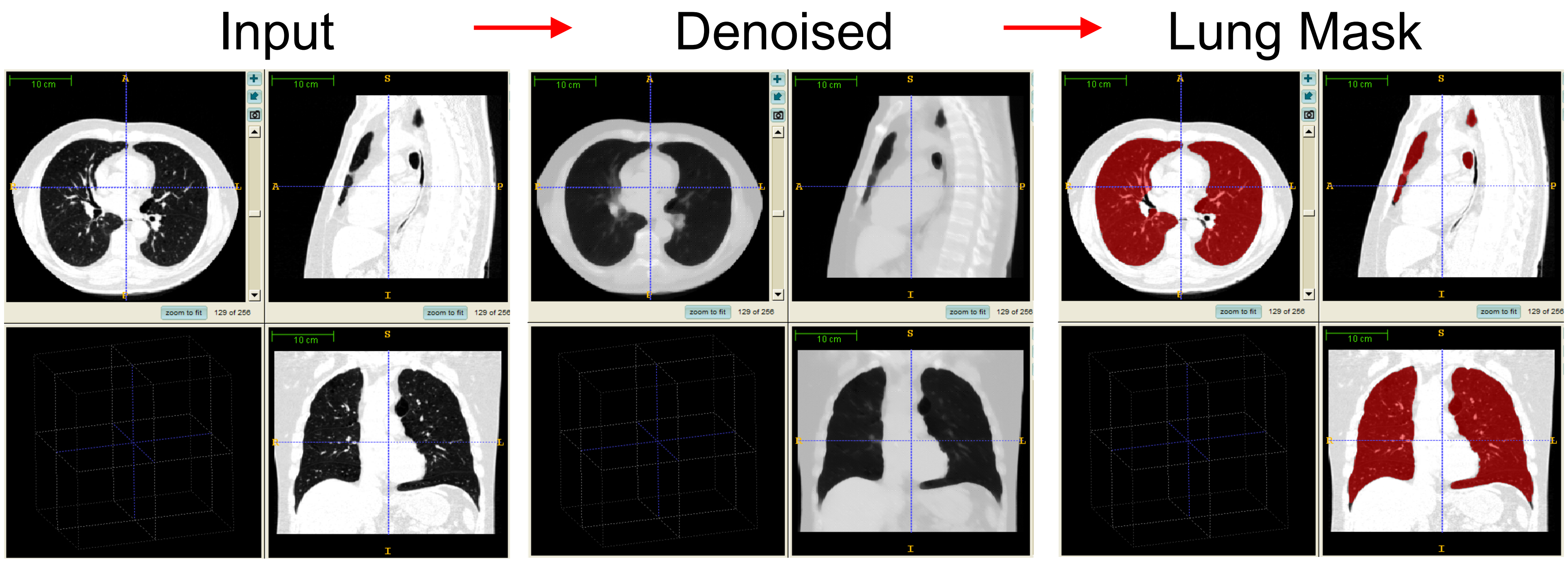
Our overall aim for the KU is to extract the lung and pulmonary vessel structures from a 3D CT volume





Recap: KU Sheet 1

- Goal was: Lung Mask Extraction from CT Volumes using our ROF Denoising from the Lecture
- Now we have a binary lung mask indicating where we want to enhance tubular structures, i.e. the vascular structures in the lung.



KU Sheet 2 – Task Description

- Implement one of our offset medialness based tubular structure enhancement algorithms (Algorithm 2 or 3) discussed during the lecture.

- If you want to receive full marks for Sheet 2, you have to implement Algorithm 3!
  - Algorithm 2 alone will give enough marks to be positive for this KU Sheet 2

- In both cases, you have to:
  - Precompute Gradients and Hessian Matrix of the input image (find appropriate simpleITK filters)
  - Compute the Hessian Eigendecomposition for all voxels inside the lung mask
  - Analyze orthogonal plane to tubes' main direction (i.e. the Eigenvector from smallest Eigenvalue): this requires interpolation of voxel intensities
  - Compute the final medialness according to Algorithm 2 or 3

KU Sheet 2 – Task Description

- Embed your computations inside a multi-scale framework (image pyramid, see simpleITK) to get vessel responses at different sizes (radii)

- Multi-scale medialness uses the maximum over scales. Think carefully about how to correctly interpolate across scales (with different image resolutions)!

- Finally, perform a non maximum suppression of multi-scale medialness to get a hint of the centerline. While this could be an input to a queue-based reconnection, computing the centerline is NOT required for full marks in this KU sheet.

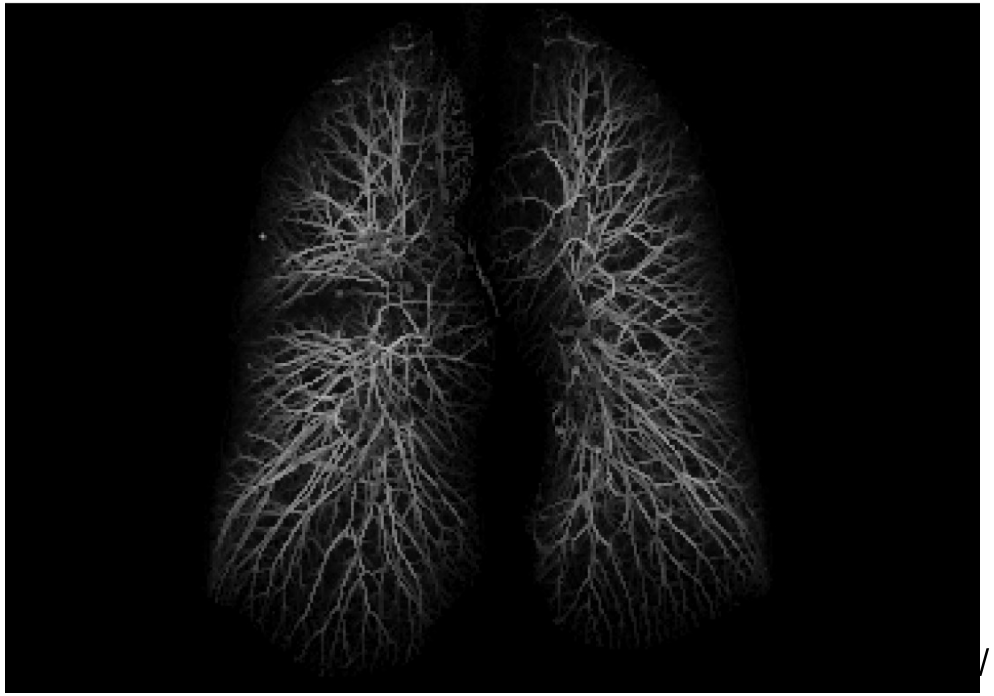
KU Sheet 2 – Hints

- To simplify, use a pyramid with sampling factor 2
  - Choose a σ around 1 voxel and set $\gamma = 1$
  - You may want to experiment with slightly different σ for your report
- Per scale try to use different radii assumptions (e.g. 1, 1.5, 2 voxels), which leads to different results for your report
- Use simpleITK filters where possible, but some parts have to be implemented on your own (Eigendecomposition, trilinear interpolation, …)
- You are not allowed to use any precoded vascular structure enhancement filters from any sources!
- Note: Processing is computationally demanding, start with lower resolutions for development (you need resampled lung masks for that)!

KU Sheet 2

- This is an example how the result of Vessel Enhancement (Algorithm 3) could look like:

- Here is the same example after non maximum suppression:



KU Sheet 2 - Tools

- Use ITK-Snap for visualizing results
- ImageJ (http://rsbweb.nih.gov/ij/), 3DSlicer (www.slicer.org) or VTK (www.vtk.org) can be used for 3D visualization of medialness
    - ImageJ -> convert to Nifti format with ITKSnap (or install the extra plugins for MetaImage format from http://ij-plugins.sourceforge.net/plugins/3d-io/index.html)

KU Organization

- Study the different parameters in the algorithm and discuss them in the report.
- Hand in is via **github**. The same rules and conventions as for Sheet 1 apply.
- The hand in date for Sheet 2 is: **Friday, 24.02.2023, 23:59**
- Please ask questions by EMail to martin.urschler@tugraz.at
  - If something has to be clarified, I will contact the whole group of KU students with the question and the answer!