Medical Image Analysis (MIA)

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KU Sheet 1

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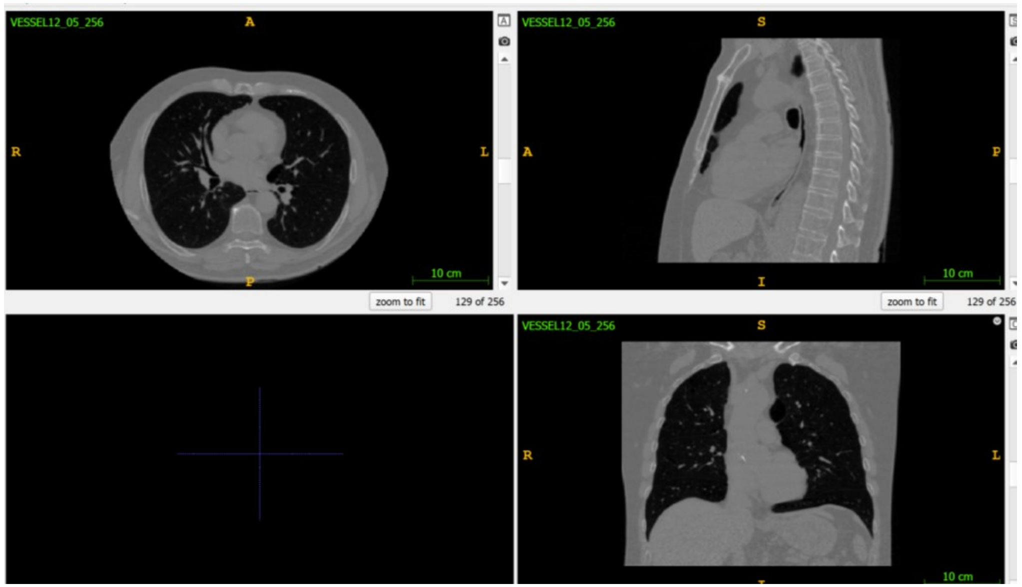
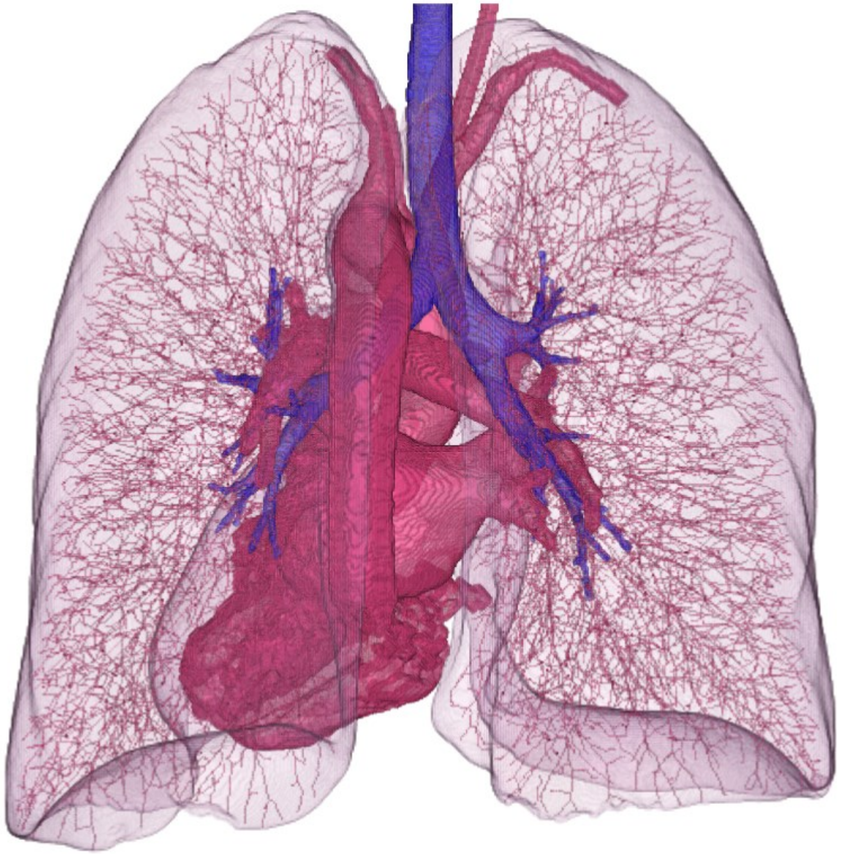
KU Exercise

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





3D CT volume in ***MetaImage*** (mhd) format

KU Organization

- **Software**: Python or C++ (each team can choose)
    - Python is the preferred language, since it is simpler to program
    - However, in C++ it is easier to get the code to run fast!

- There is a simple Python template code in the github repository with the material
    - If you want to work with C++, please get in touch with me, and I will provide some extra code and information

- KU related questions can be asked after our block lectures, or by EMail
    - If there is interest, I may consider to schedule a weekly office hour (which I could already start in the first week of January, if required)

- Of course, plagiarism is not allowed and will be checked!

KU Organization

- The KU will be organized in **groups of 2 students**, please form teams

- There will be 2 sheets of tasks, first we will perform a lung segmentation (this sheet), and later we will do the enhancement of the vascular structures (Sheet 2)
- For each sheet, the group hands in the source code and a written PDF document (word or anything else than pdf will not be assessed!)
  - Content of PDF:
    - Task Description (keep it short, just enough to give a reader some context, you may want to refer to lecture notes)
    - Input and Output Images (if applicable), if you tried it on additional images that you find on the web, describe those!
    - Description of the algorithms (again keep it restricted, but give an overview what you implemented)
    - The outcome of the required experiments, what did you learn?

KU Organization

- Hand in is via **github**. Use a github repository with all your code, datasets and the pdf report and send me the git URL via EMail on the due date. I will clone it and use it for assessment **as is**. Note that your code has to run out of the box (including Python dependencies in the requirements.txt file, if you have additional ones!). I do not want to spend time to get your code running!

- The hand in date for Sheet 1 is: **Wednesday, 18.01.2023, 23:59**

- You can download Python template code and the CT volume from this public (but read only) github repository: https://github.com/martinurschler/MIA2022_KU_Template

    - You may want to clone it, and then push your changes to your own repository
    - Use Github Issues for comments, requests or if you find a bug

KU Organization

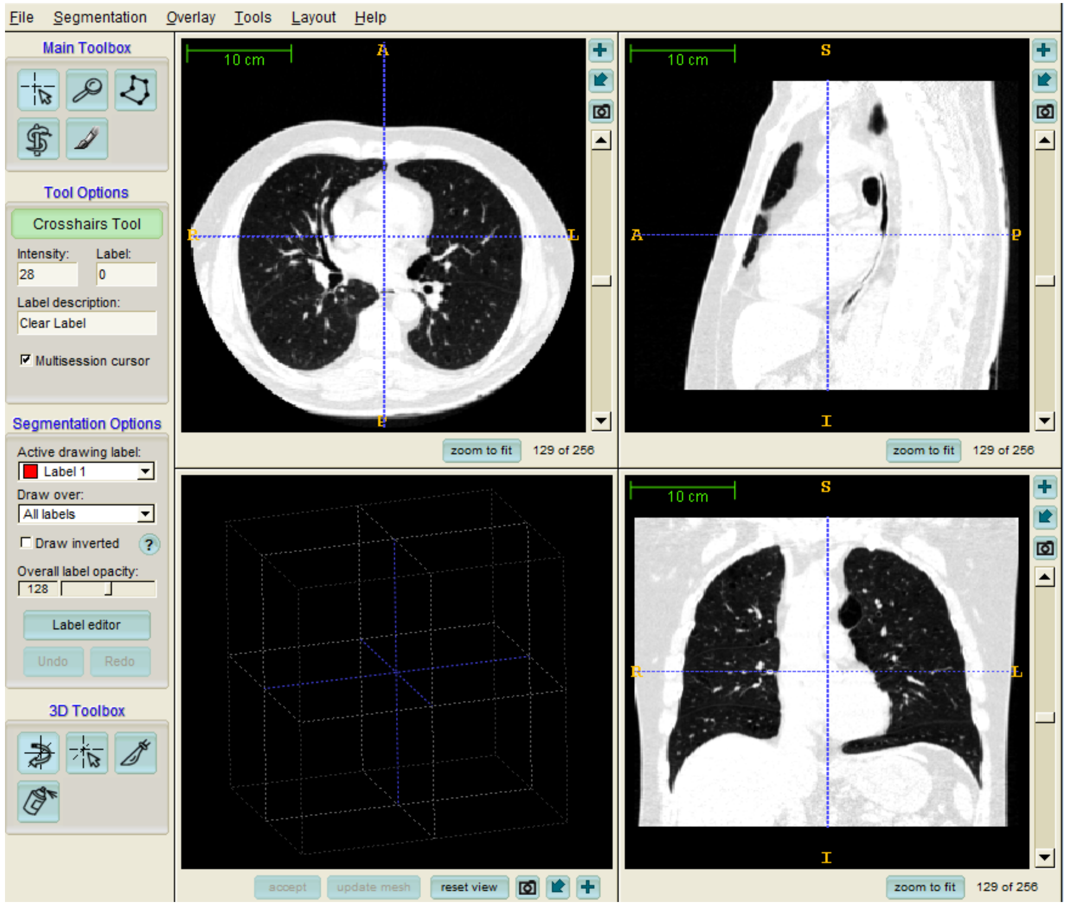
- We use Python and the ITK toolkit via the SimpleITK package
  - If you want to use C++ instead, have a look at the cmake system www.cmake.org for creating platform independent makefiles, and you also have to install ITK from www.itk.org

- ITK is a powerful library for image segmentation, processing and registration, written itself in C++, but providing Python wrappers (e.g. SimpleITK)

- Have a look at the documentation for SimpleITK first (https://simpleitk.org)

KU Organization

- Another important tool to use **is ITK-Snap** for visualizing 3D volumes
  - You can use other tools as well, but this one is simple to learn and comes from the developers of ITK
  - Install ITK-Snap from www.itksnap.org
  - You can open our sample CT volume (see path 'data' in code template) and inspect axial, sagittal and coronal views of the 3D volume



  - Important: Study 'Image Information' and 'Image Contrast' under 'Tools', the latter can be used for **different greyvalue mappings** to focus on vessels, soft tissue or bones (Short-cut 'Ctrl-I')

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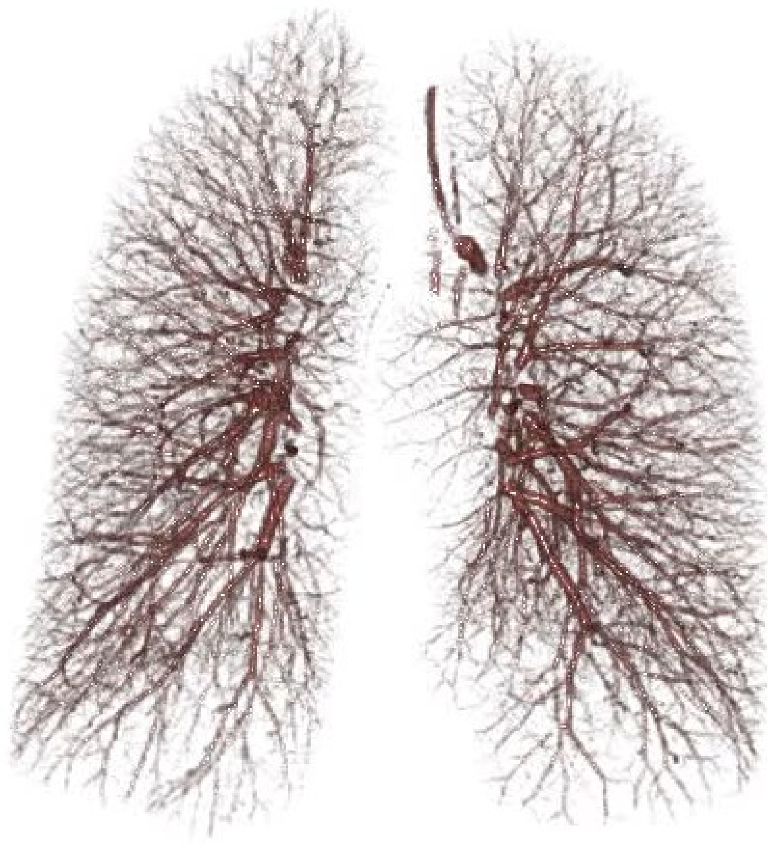
- Our aim is to enhance vessel structures
- Our first task is to restrict computation of vessel structures solely to the lung!
- So we need a **lung segmentation**!



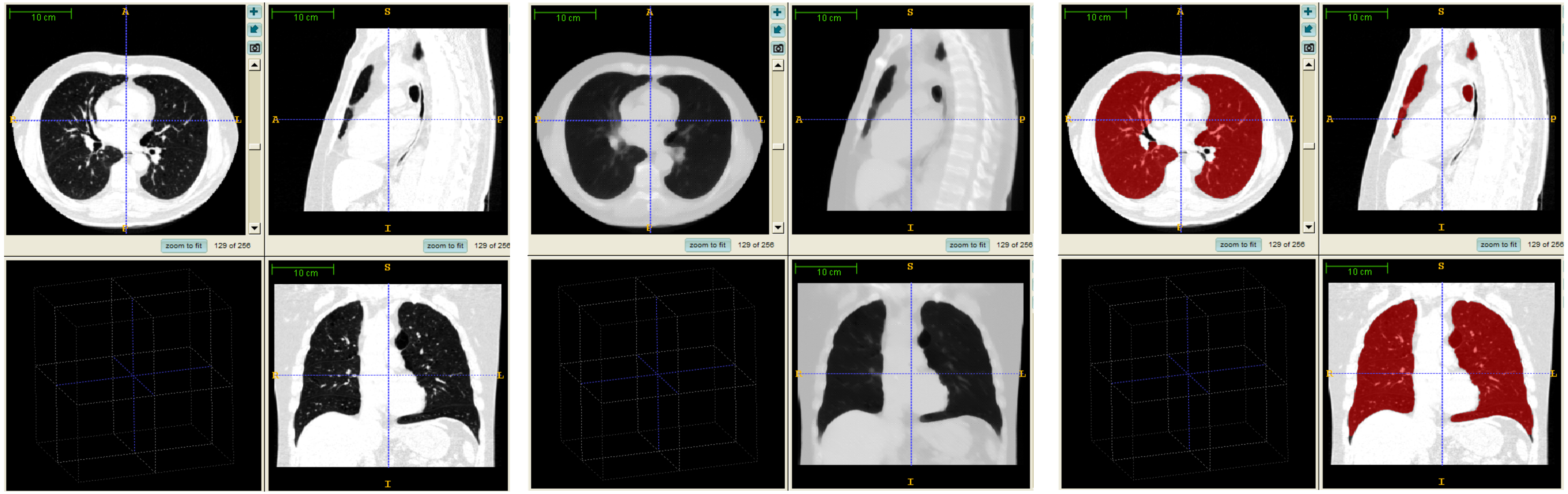
Video

KU Sheet 1

- Goal: Lung Mask Extraction from CT Volumes Using our ROF Denoising from the Lecture

- Our input volume is called ‘VESSEL12_05_256.mhd’ and is stored in MetaImage format (the volumetric image format defined by ITK), it has a size of 256x256x256

Input → Denoised → Lung Mask



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- ROF Denoising removes small lung details, i.e. vessels, the large remaining dark structure is the lung
  - Read the input volume with the sitk ReadImageFilter (see code template)
  - Convert the input volume (a 16 bit integer with values between ca. -1000 and +1000, representing Hounsfield Units) to a float volume scaled between 0.0 and 1.0
  - Implement the ROF primal-dual algorithm from the lecture
  - Use simpler timesteps than the scheme described by Zhu and Chan: tau_p = 0.02 and tau_d = 2.0
  - Use a lambda (weighting data fidelity term and regularization term) in the range between 0.1 and 10.0, perform experiments studying the effect of several of these different lambdas!
  - The nrIterations can be fixed to a few 100, e.g. 300 to 500. You may want to study the effect of the number of iterations to get a feeling when to stop (or optionally think about a convergence check!)

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- After ROF Denoising:
  - Apply an Otsu Threshold (ITK filter) to get dark regions, 128 bins are a reasonable bin size for the histogram
  - Use Shape Labeling (i.e. Connected Component Analysis) to find the connected components in the thresholded segmentation image
  - Choose the lung according to labeled shape sizes (the background is the largest dark region)
  - Optionally: Refine the lung segmentation by region growing with the ITK, to fill some gaps near the diaphragm for example (don’t forget to describe it in your report). For **full marks**, the region growing is required!

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- This is how the result of lung segmentation should look like, you can visualize it if you write the segmentation as a binary image (datatype can be uint8 or uint16) and if you open it as a segmentation in ITK-Snap (this overlays the segmentation)

use this button
to create 3d rendering
of segmentation