Automatic software for the detection of bioprosthesis valve calcification

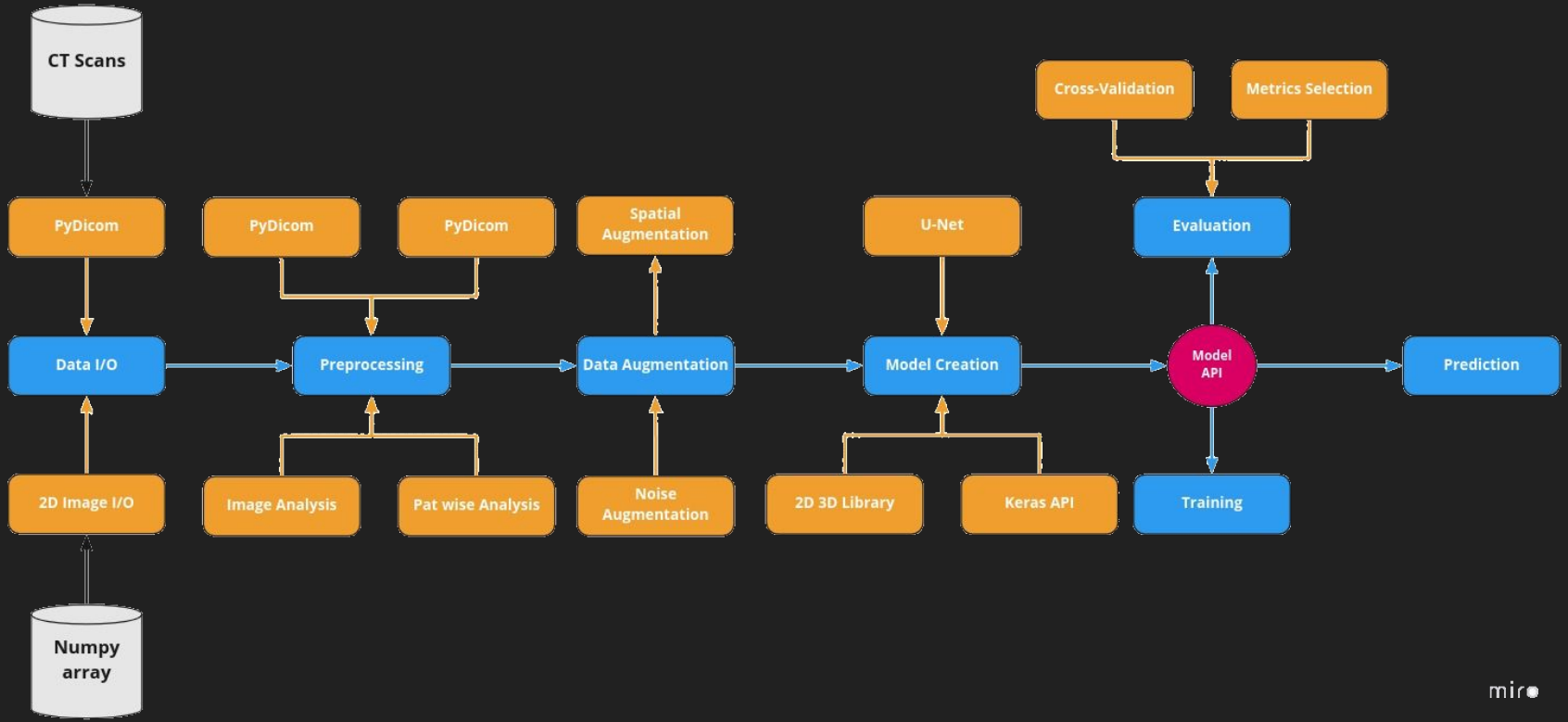
Goal

- Develop an automatic software to quantify bioprosthesis valve calcification
- Quantify bioprosthesis valve calcification using AI state-of-the-art techniques
- Validate the automated software against expert reading and patient’s outcomes for the valve calcification
- Validate and predict the link between the quantitative bioprosthetic leaflet and clinical outcomes, as well as its possible interaction with sex.

Overview

- Big picture / Pipeline
- DICOM Standard
- Viewer
- Processing of data
- Labeling
- AI model + Algorithms
- Results
- Link with clinical outcomes
- Challenges
- Next steps

Pipeline

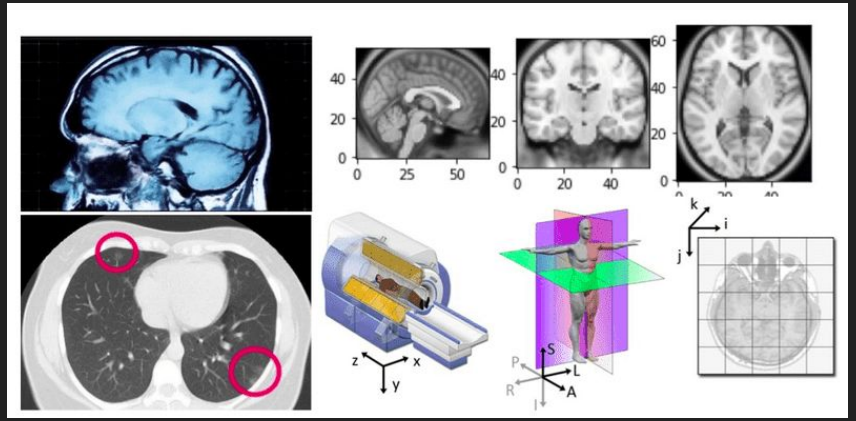


DICOM format

- Acronym for Digital Imaging and Communications in Medicine

- Data interchange protocol, digital image format, and file structure for biomedical images and image-related information.

- CT images which are a measure of radio-density, calibrated to distilled water and free air.



Viewer

- Wrapper of VTK library
- VTK : Process images and create 3D computer graphics with the Visualization Toolkit
- Working with polygonal meshes and point clouds
- Working with volumetric data and tetrahedral meshes
- Plotting and histogramming in 2D and 3D

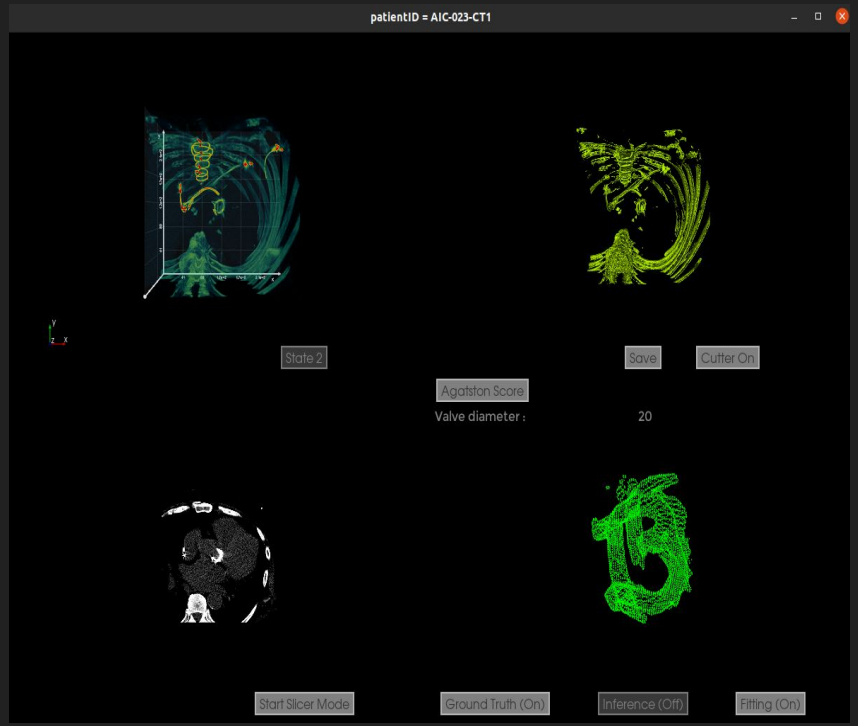
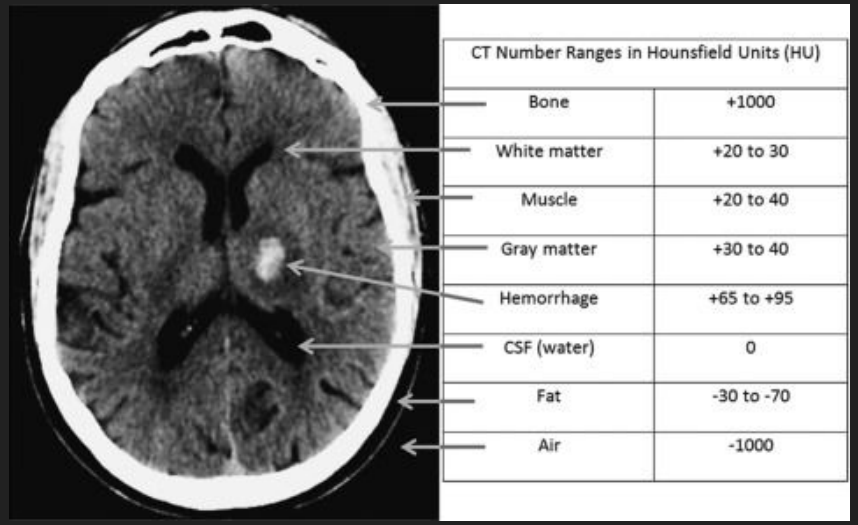


Image processing

- The unit of measurement in CT scans is the Hounsfield Unit (HU) which is a measure of radiodensity.
- Each voxel (3D pixel) has a value that is the measure of the reduction intensity of a ray of light by the tissue through it passes.

- HU = m * P + b
  - m is Rescale slope
  - b is Rescale intercept
  - P is the value of that particular pixel in the pixels array.
- Rescaling HU between 0-255

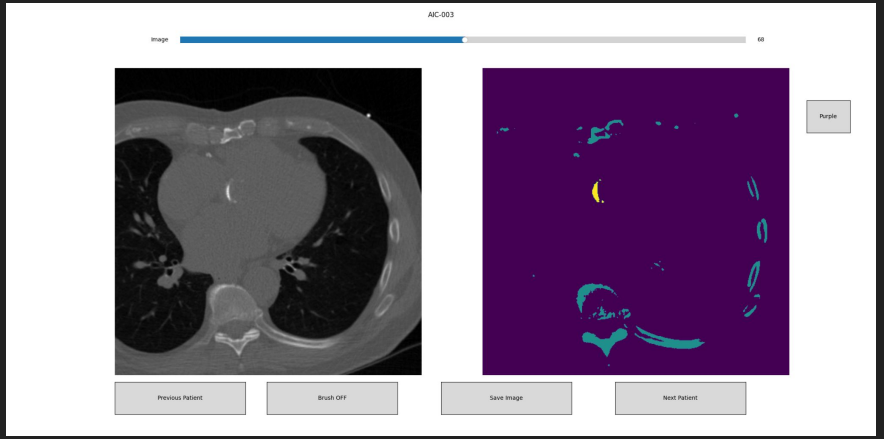


CT Number Ranges in Hounsfield Units (HU)	
Bone	+1000
White matter	+20 to 30
Muscle	+20 to 40
Gray matter	+30 to 40
Hemorrhage	+65 to +95
CSF (water)	0
Fat	-30 to -70
Air	-1000

Labeling

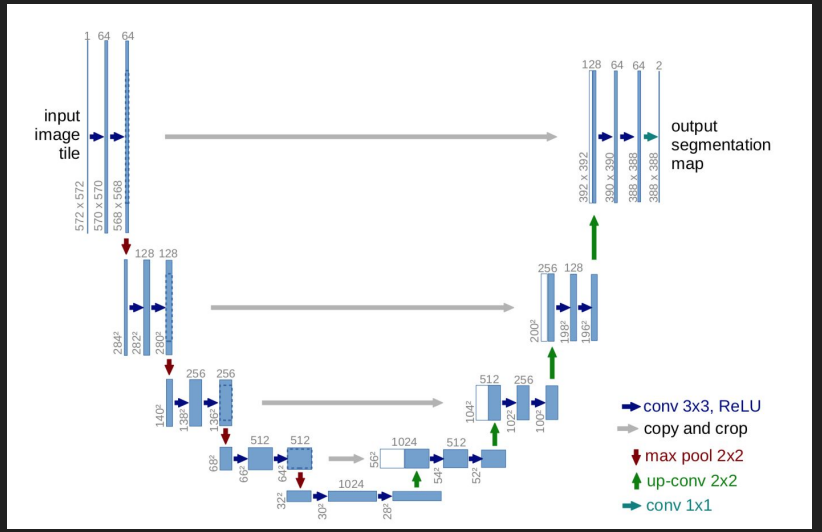
- Semi automated process

- With the aid of cardiologic expert, provide high quality of datasets



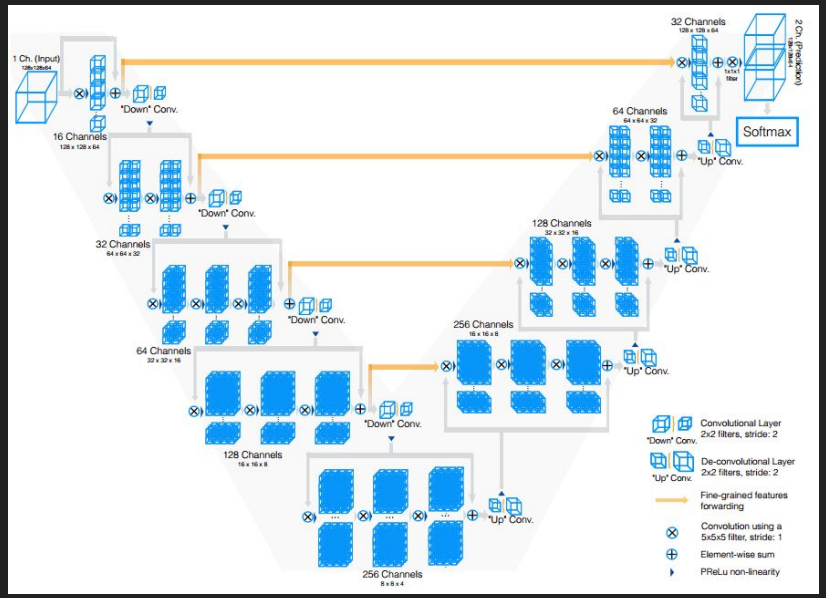
2D Model

- U-Net model
- U shape.
- The architecture is symmetric
  - Consists of two major parts
  - Encoding (Downsampling)
  - Decoding (Upsampling)
- Good candidate because able to localise and distinguish borders is by doing classification on every pixel, so the input and output share the same size.



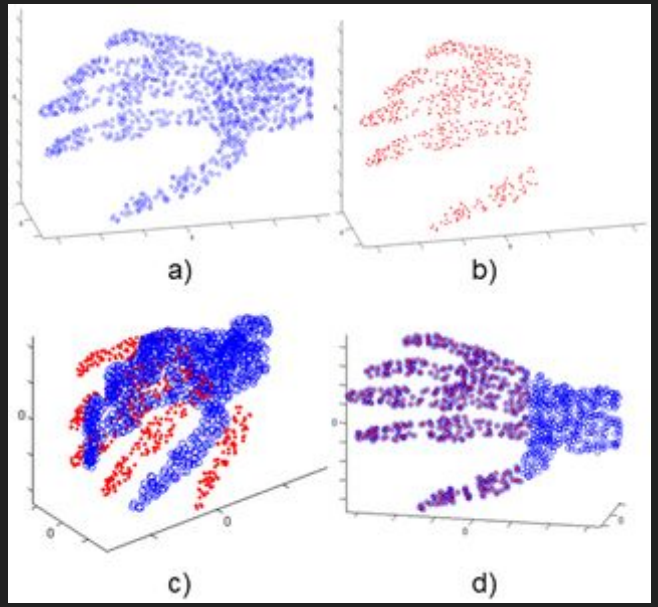
3D Model

- V-Net model
- Extends of Unet to process 3D MRI volumes.
- In contrast to processing the input 3D volumes slice-wise, use 3D convolutions.
- Slice-wise processing is sub-optimal.



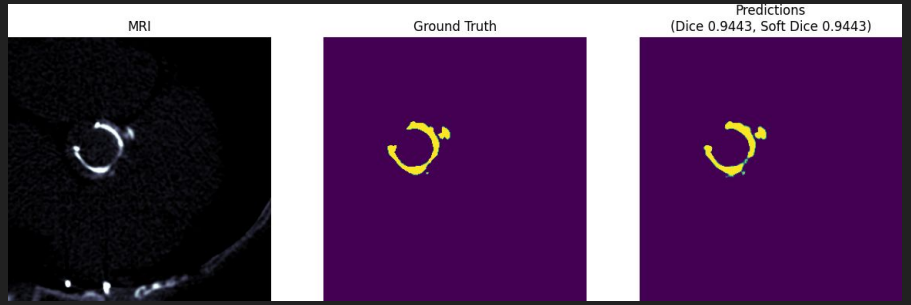
ICP

- Iterative Closest Point registration algorithm.
- Input are two valves and an initial transformation . One of them is a clean valve.
- Output is a refined transformation that tightly aligns the two valves.
- Using that algorithm, we can remove matching point clouds pairs and remaining points are due to calcification

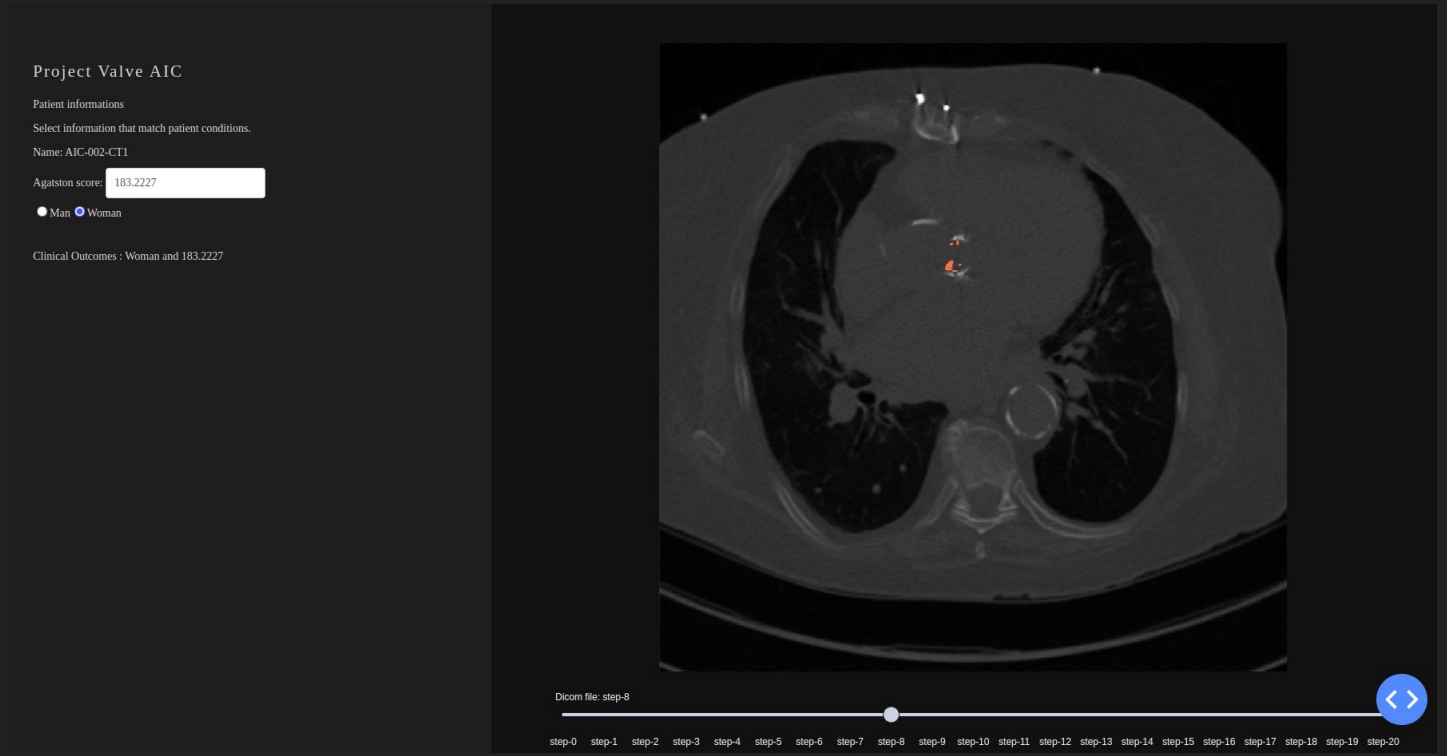


Prediction (AI + Fitting)

- TODO



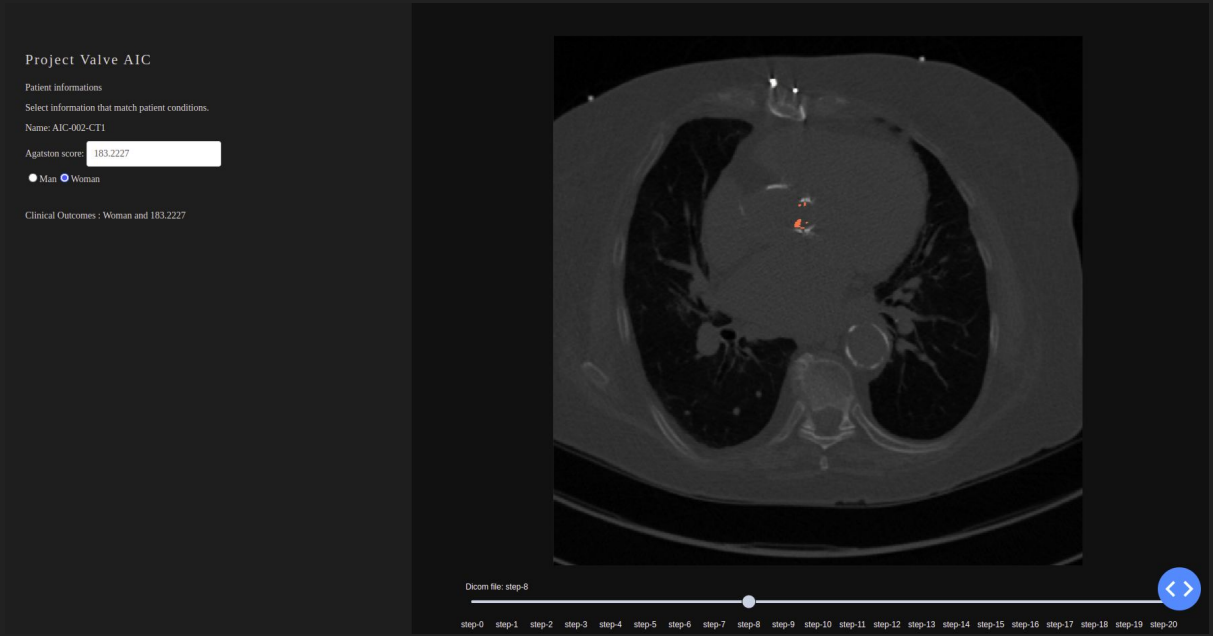
Prediction


Project Valve AIC
Patient informations
Select information that match patient conditions.
Name: AIC-002-CT1
Agatston score: 183.2227
Man
Woman
Clinical Outcomes : Woman and 183.2227
Dicom file: step-8
step-0 step-1 step-2 step-3 step-4 step-5 step-6 step-7 step-8 step-9 step-10 step-11 step-12 step-13 step-14 step-15 step-16 step-17 step-18 step-19 step-20

Clinical outcomes

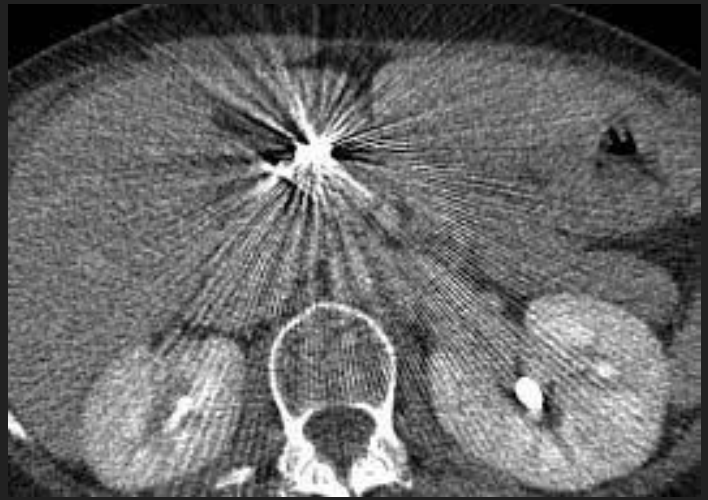
“Bioprosthetic AVCd is strongly and independently associated with HVD and the risk of death or valve re-intervention.”

Zhang B, Salaun E, Côté N, Wu Y, Mahjoub H, Mathieu P, Dahou A, Zenses AS, Clisson M, Pibarot P, Clavel MA. Association of Bioprosthetic Aortic Valve Leaflet Calcification on Hemodynamic and Clinical Outcomes. J Am Coll Cardiol. 2020 Oct 13;76(15):1737-1748. doi: 10.1016/j.jacc.2020.08.034. PMID: 33032735.



Challenge

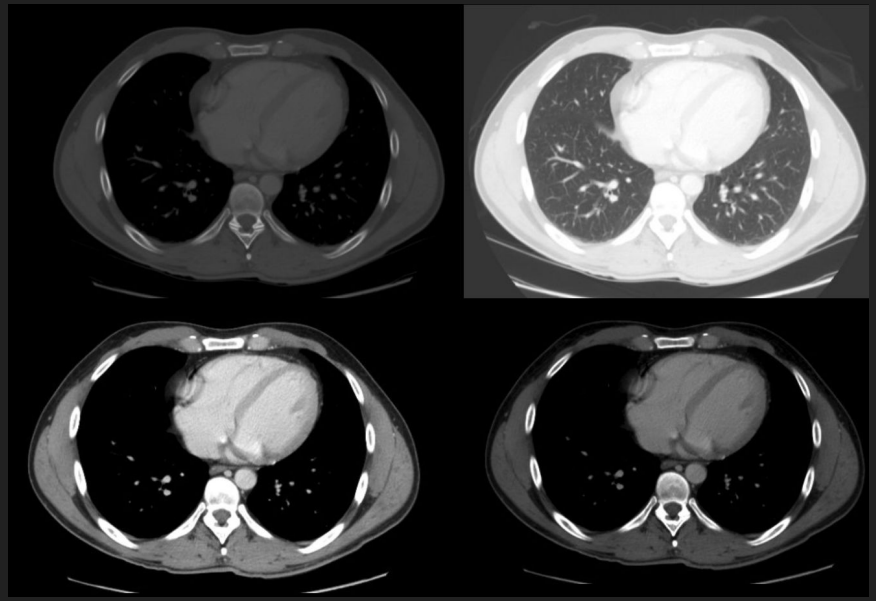
- Metal streak artifacts caused by multiple mechanisms including beam hardening, scatter, Poisson noise, motion, and edge effects.
- Various type of valves : Multi-class semantic segmentation
- Quantity of data points with associated labeling.
- Bias in dataset (sex, gender, …)



Next steps

Windowing techniques

“Practical Window Setting Optimization for Medical Image Deep Learning”



Hyunkwang Lee, Myeongchan Kim, Synho Do: “Practical Window Setting Optimization for Medical Image Deep Learning”, 2018;