Detailed Annotations of Chest X-Rays via CT Projection for Report Understanding

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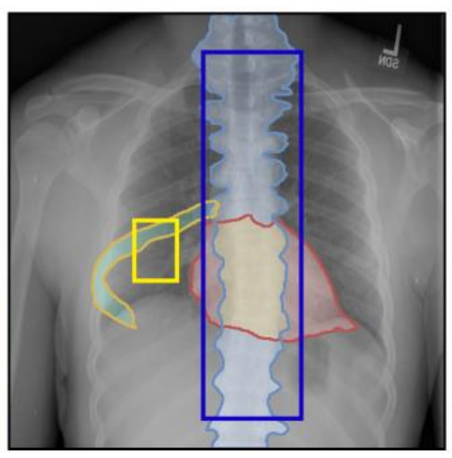
Motivation

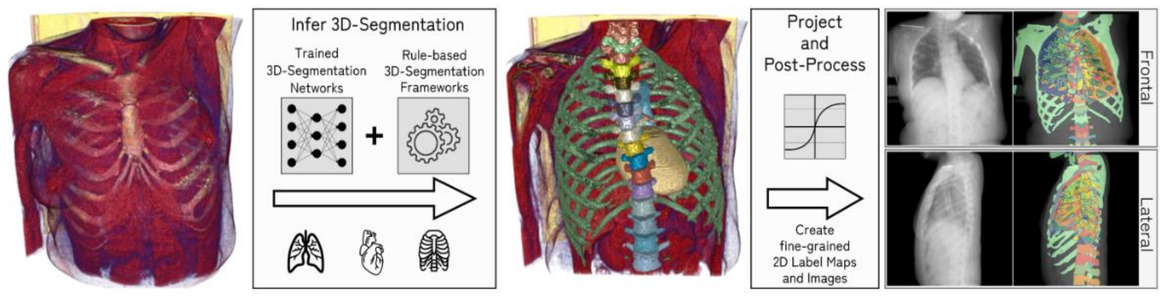
- Radiologic reports often follow defined structures
  - ABCDE-Scheme
  - Clot Burden Score
  - …
- Reports depend on description of correlation of anomalous findings and corresponding anatomical structures
- While there exists work on the localization of anomalies, the identification of anatomical structures can be difficult
  - Missing annotations (3 hours to annotate single image manually)
  - Hard to learn implicitly

Medical Report Findings:

Heart size within normal limits. Mild levocurvature of the spine. A 9 mm pulmonary nodule is noted partially overlying the posterior 6th right rib on the frontal view.

Observation:	Normal	Mild Levo-curvature	Pulmonary Nodule
Anatomy:	Heart	Spine	Posterior 6th right rib



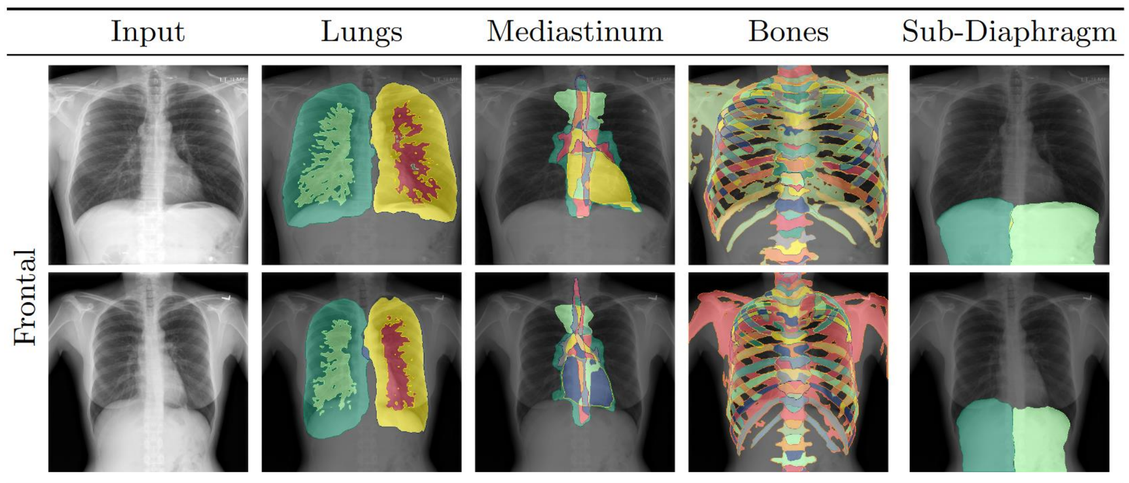


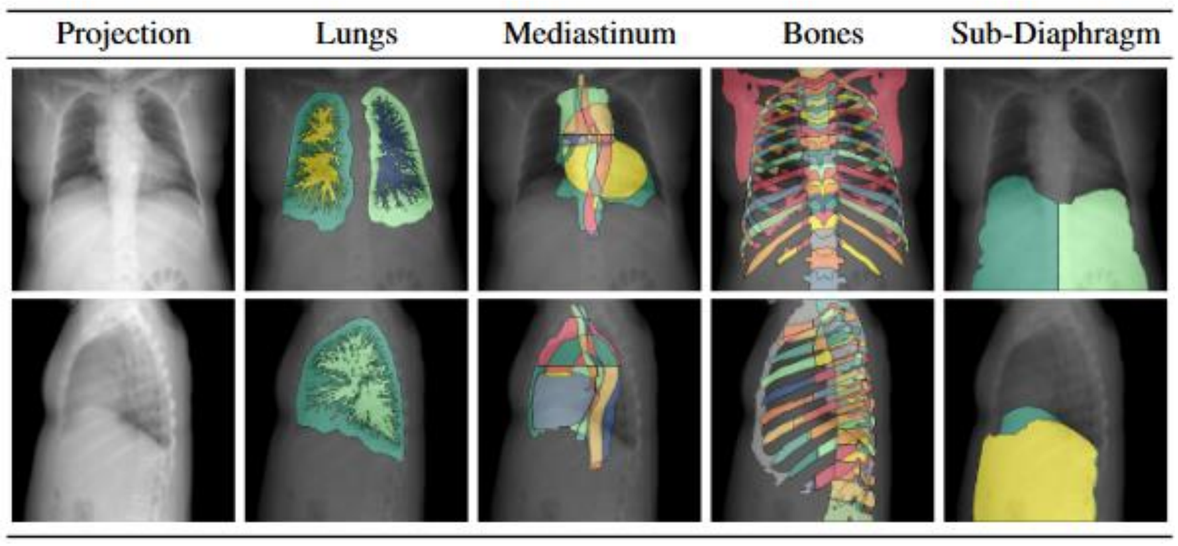
Automated X-Ray Dataset Generation

- We propose a pipeline using segmentation models in the CT domain and then to project both the volumes and the labels to a 2D-plane to simplify the segmentation of structures in X-Ray images
- Utilization of nnUNet, rules and established segmentation models for different anatomical structures
- We introduce PAXRay – A multi-label segmentation dataset of 880 images with 166 anatomical labels in frontal and lateral view
- Main categories:
  Lungs, Mediastinum, Bones and sub-diaphragm

Segmentation of Anatomical Structures

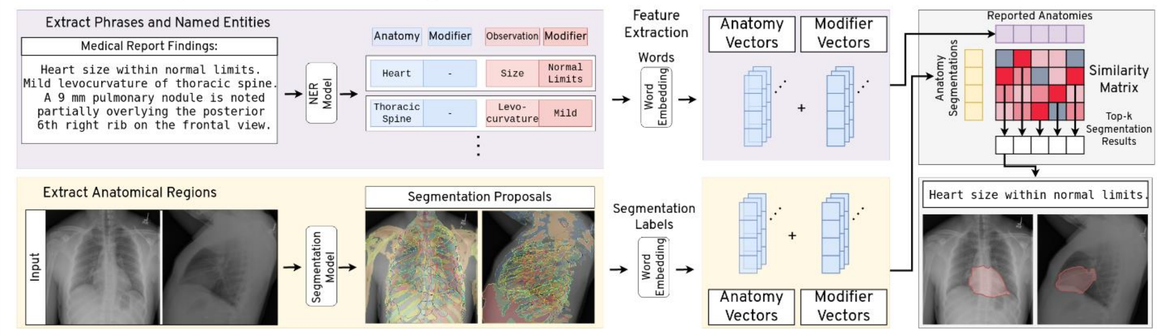
- Multi-Label segmentation task due to large amount of overlapping structures
- Models: Unet and SemSegFPN with ResNet-50 backbone
- Binary Cross Entropy and Dice Loss
- Segmentations translate to real X-Ray images





	Init.	Lung		Mediastinum				Bones		Sub-Dia.	Mean
		Lobes	Vessels	Regions	Heart	Aorta	Airw.	Spine	Ribs		
SFPN	(Random)	82.3	49.5	68.6	81.8	67.8	55.6	84.8	69.4	93.9	37.8
	(VBData)	86.3	**52.1**	74.6	88.9	79.0	70.0	90.5	78.8	96.2	51.9
UNet	(Random)	85.0	49.8	74.8	87.7	77.9	68.8	90.0	81.5	95.6	54.5
	(VBData)	**86.9**	50.8	**77.3**	**89.9**	**80.8**	**73.2**	**92.5**	**84.9**	**96.7**	**60.6**

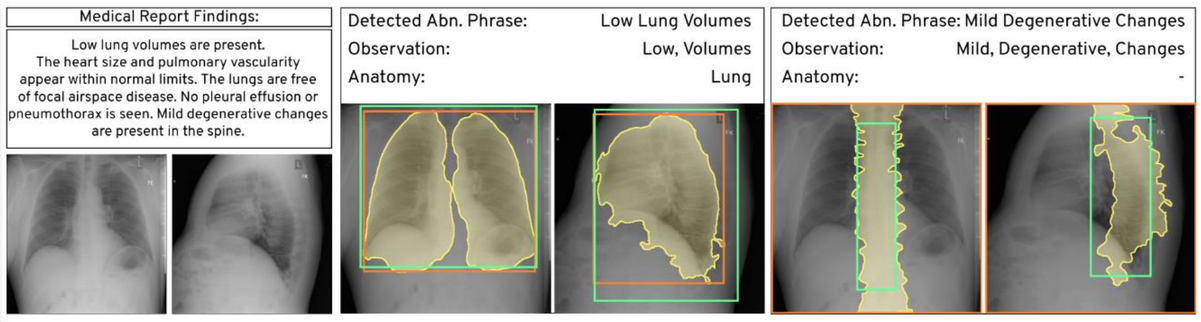
Anatomy Grounding Baseline



	Method	Box Proposals	Text Features	Top-1_{25}	Top-1_{50}	Top-1_{75}	Top-5_{50}	Top-10_{50}
Frontal	Whole Image	None	None	18.5	7.1	0.5	7.1	7.1
	Oracle	Sel. Search	None	72.8	16.5	7.7	16.5	16.5
	PhraseDist	Anat. Seg.	BioSent	36.5	17.9	2.9	23.3	27.5
	Anat.Dist	Anat. Seg.	BioWord	34.7	13.1	0.5	26.3	**28.1**
	ModAnat.	Anat. Seg.	BioWord	**38.9**	**21.5**	**4.7**	**27.5**	**28.1**
Lateral	Whole Image	None	None	23.1	8.4	1.0	8.4	8.4
	Oracle	Sel. Search	None	80.7	47.7	19.2	47.7	47.7
	PhraseDist	Anat.Seg.	BioSent	47.3	22.1	4.2	26.3	30.5
	Anat.Dist.	Anat.Seg.	BioWord	45.2	17.8	2.1	30.5	31.5
	ModAnat.	Anat. Seg.	BioWord	**49.4**	**26.3**	**8.4**	**32.6**	**32.6**

	Method(N=200)	HR_{25}	HR_{50}	HR_{75}
Frontal	Whole Image	16.5	5.8	0.4
	Selec. Search [61]	72.8	16.5	7.7
	EdgeBoxes [76]	18.9	4.8	0.9
	RPN [48]	53.8	18.9	1.4
	Anatomy Segm.	**93.2**	**66.9**	**20.8**

	Method(N=200)	HR_{25}	HR_{50}	HR_{75}
Lateral	Whole Image	23.1	8.4	1.0
	Selec. Search [61]	80.7	47.7	19.2
	EdgeBoxes [76]	35.7	11.9	1.8
	RPN [48]	68.8	24.7	0.9
	Anatomy Segm.	**88.0**	**62.3**	**20.1**



Conclusion & Outlook

- Automatic generation of labels for chest X-rays through the projection of CT data and their respective annotations via established segmentation methods to enable more complex downstream tasks such as medical phrase grounding.
- We introduce PAXRay - the first dataset for the fine-grained segmentation of anatomy for chest x-rays