

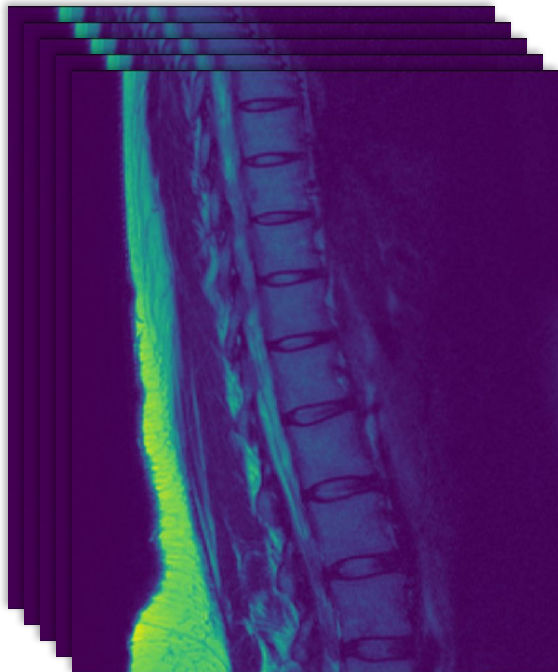
Automatische Segmentierung und anatomisches Labeling der Wirbelsäule in MRT-Ausschnitten

Brutenis Gliwa

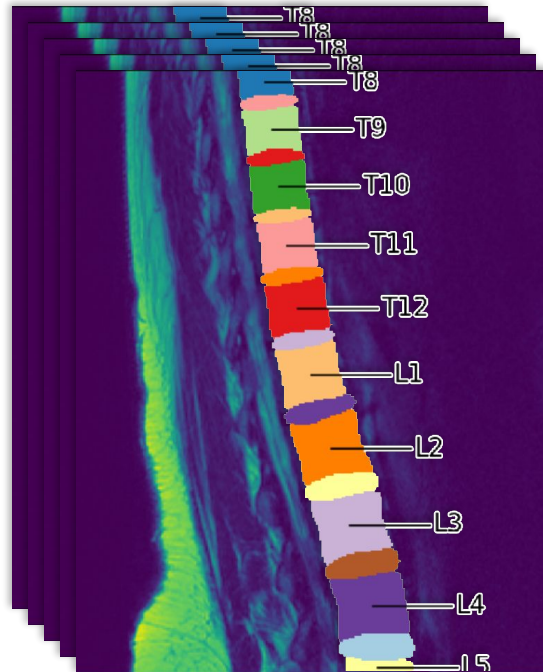
6 Dezember 2023

Automatische Segmentierung und anatomisches Labeling der Wirbelsäule in MRT-Ausschnitten

MRT



Segmentierung
und Labeling

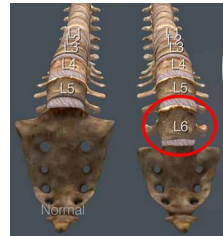
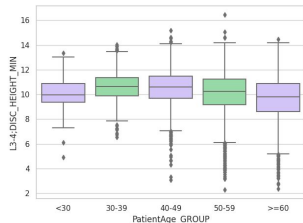


Motivation: Warum ist Wirbelsäulen-Segmentierung wichtig?

Akademisch

Automatisierte Auswertung:

- Bandscheibendicke im Vergleich zum Alter?
- Wie viele Wirbel hat ein Mensch?



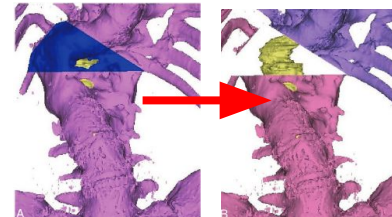
Quelle: shimspine.com



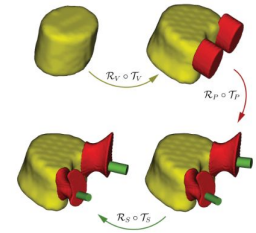
Praxis

In der Chirurgie:

- Planung von Operationen
- Schrauben in Wirbelkörpern



Quelle: [Metz et al., 2008](#)



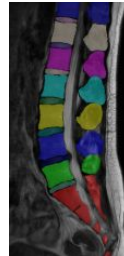
Quelle: [Knez et al., 2016](#)

Datensatz

10833 MRT-Scans



- Erstellt von der Nationalen Kohorte (NAKO)
- Ganzkörper MRTs: $\approx 20 \times 400 \times 1000$ Voxel
- Öffentliche Datensätze sind oft
 - nur $\sim 200-300$ MRT-Scans
 - nur lumbar



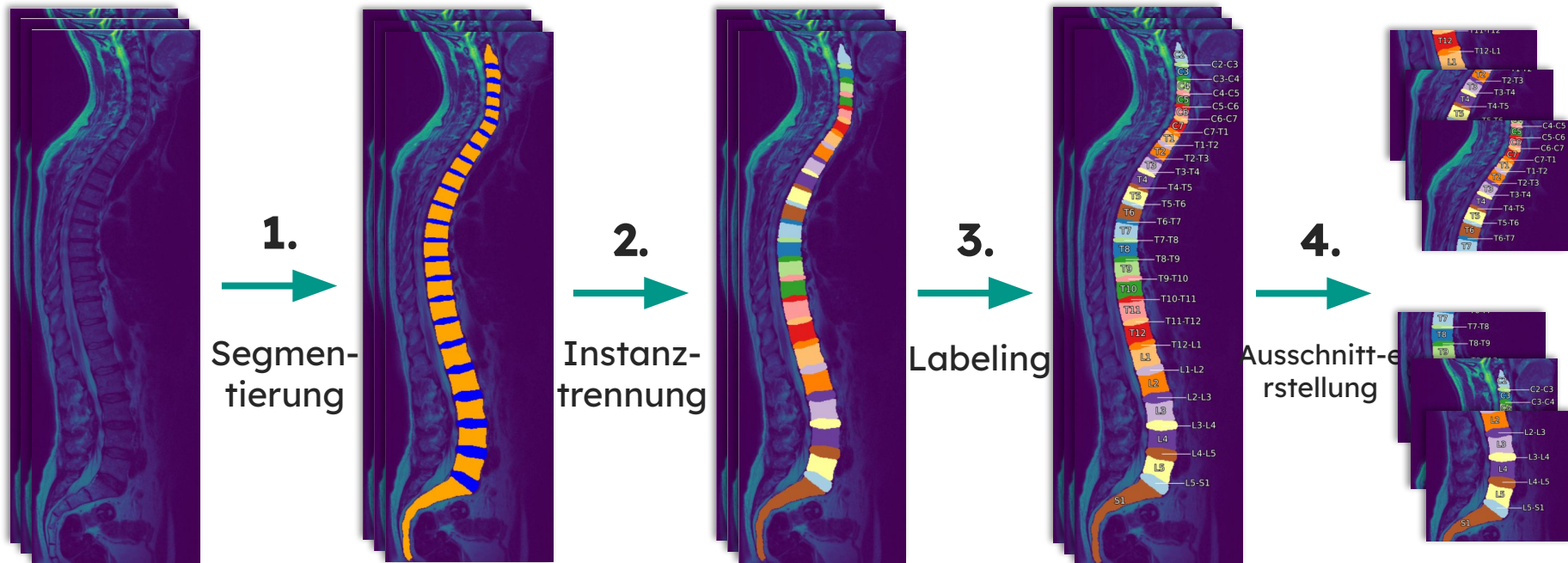
davon 162 segmentiert



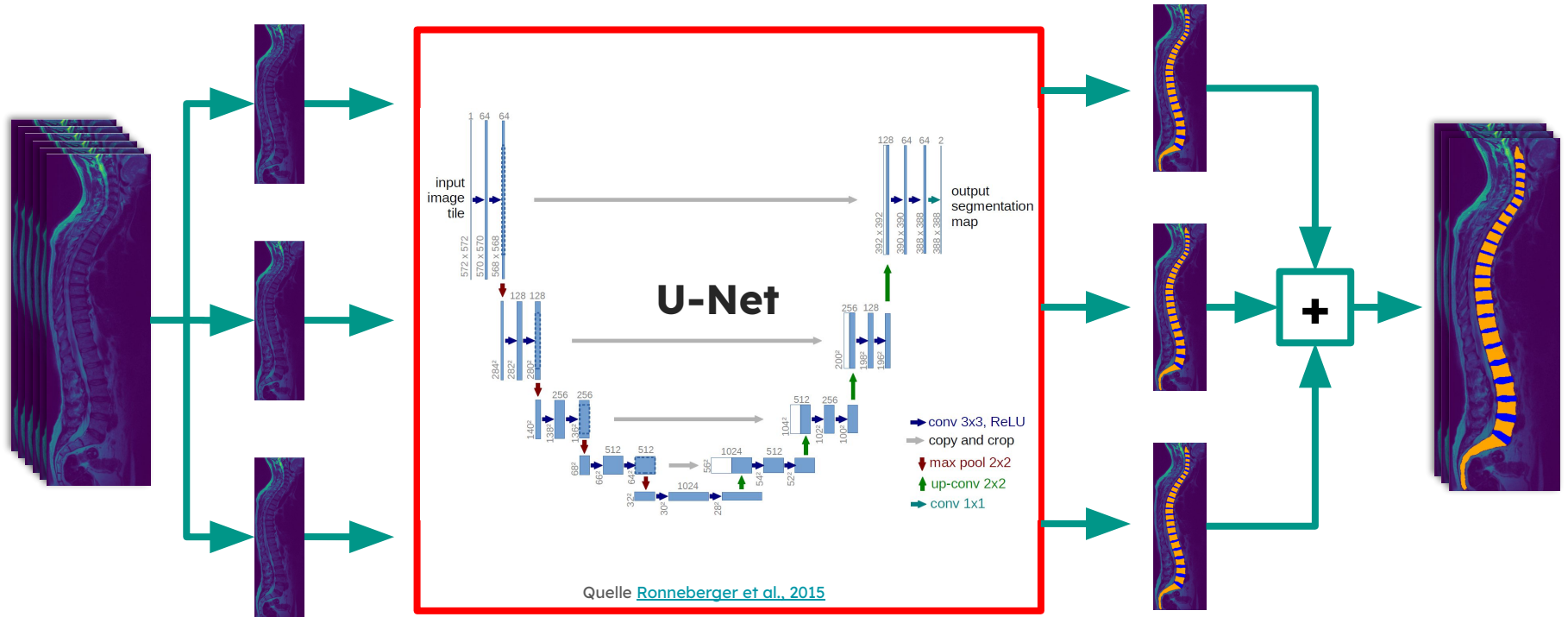
- Von Radiologen an der Universitätsmedizin Rostock erstellt
- Unterscheidung zwischen Wirbelkörper und Bandscheiben
- Keine einzelnen Instanzen

Labeling vollständiger Wirbelsäulen MRTs

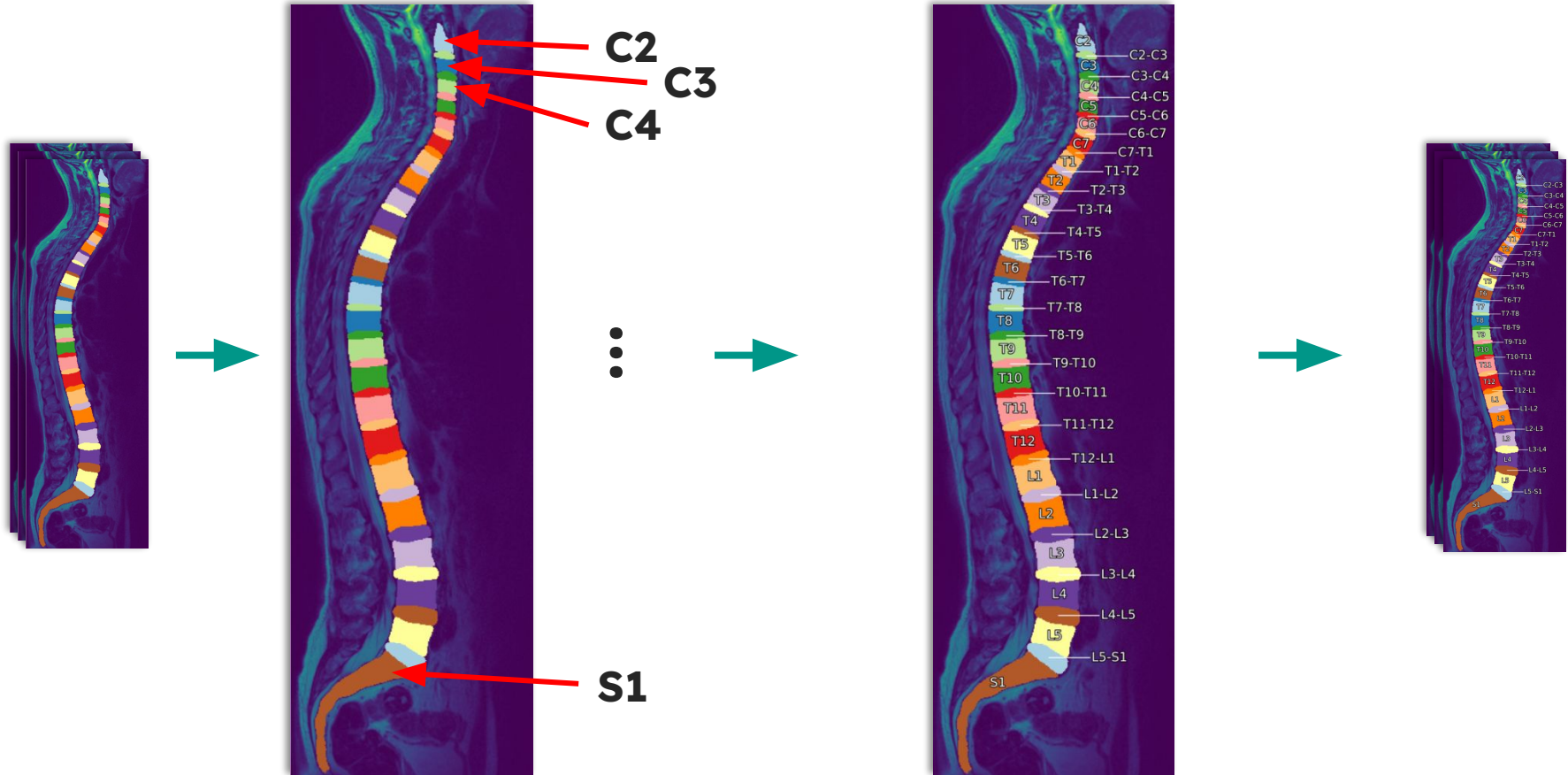
Pipeline für vollständige MRTs



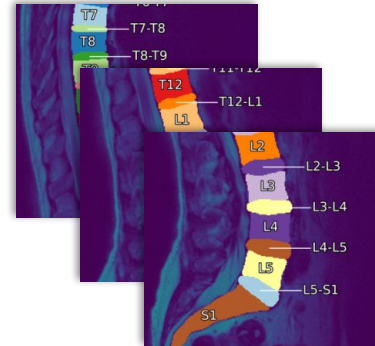
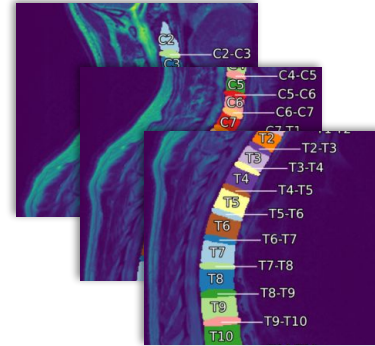
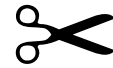
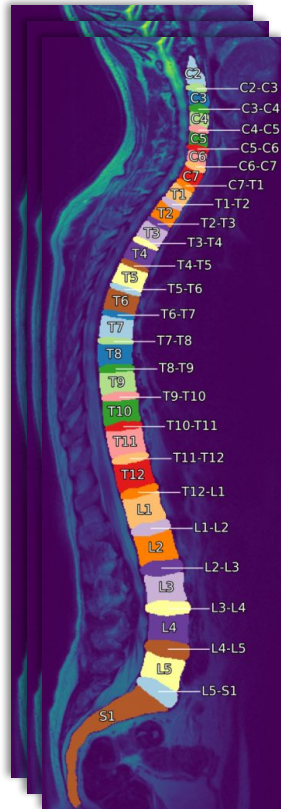
1. Segmentierung



3. Labeling der Instanzen

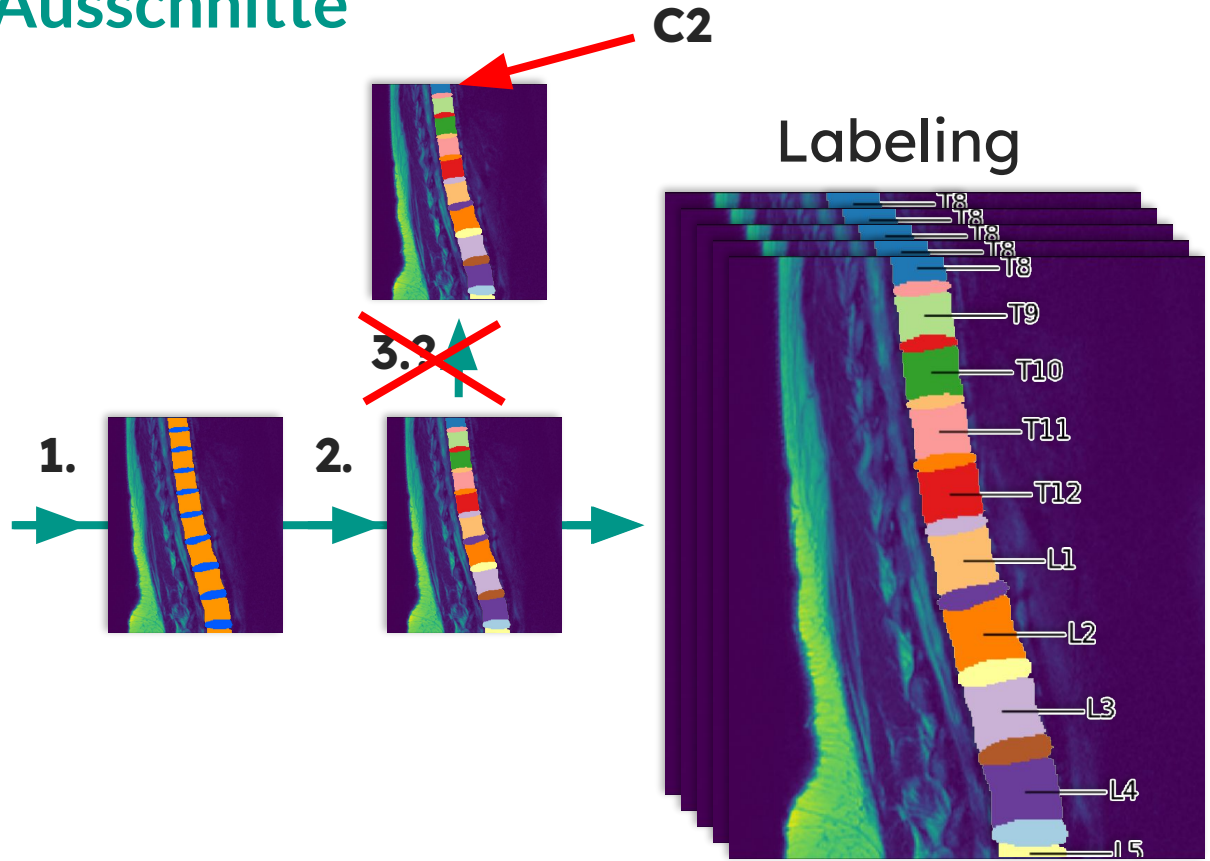
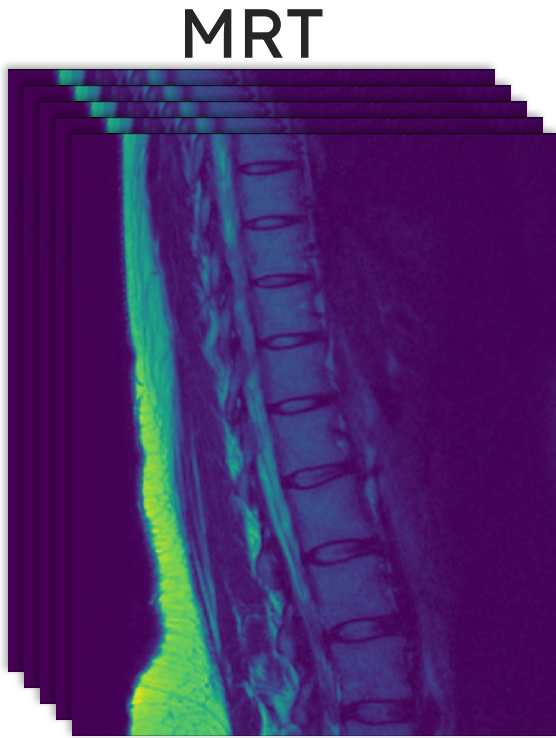


4. Ausschneiden



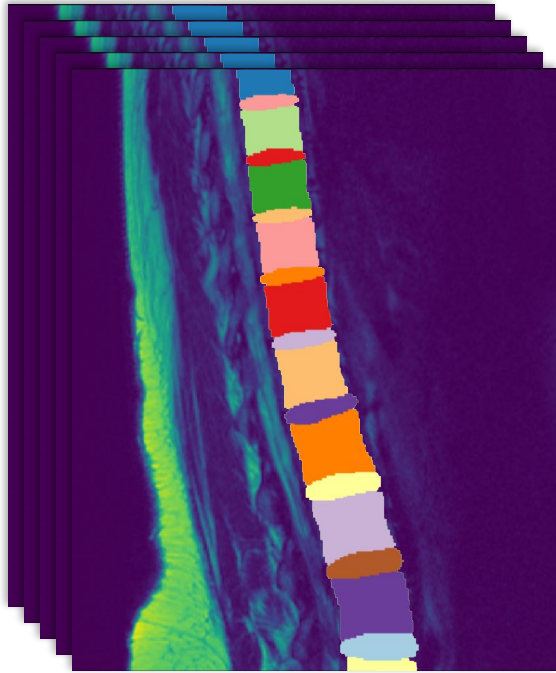
Labeling von MRT-Ausschnitten

Pipeline für MRT-Ausschnitte

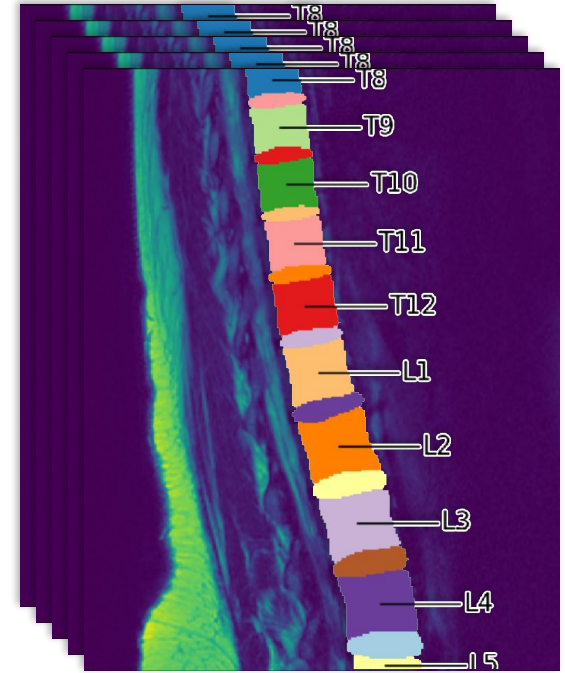


Problemreduktion

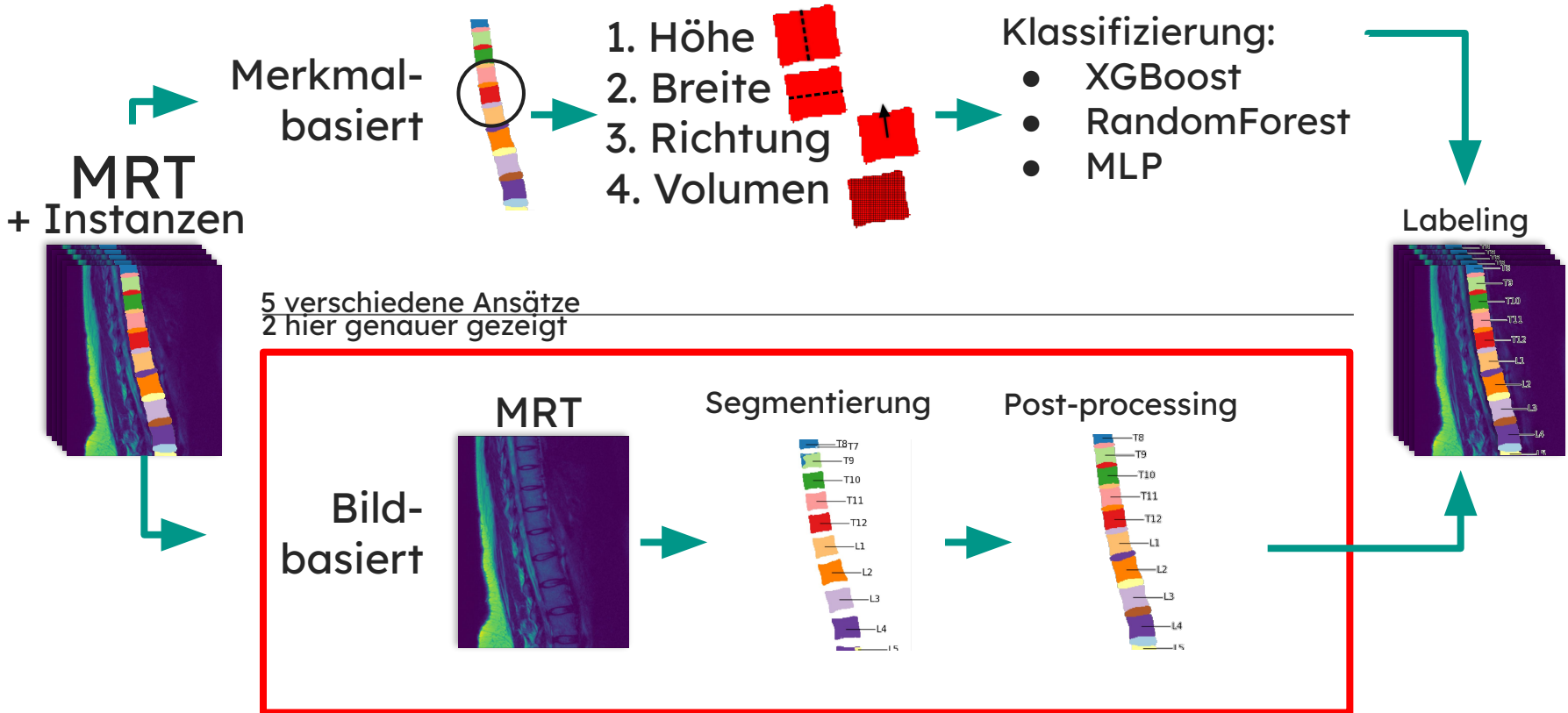
MRT+ Instanzen



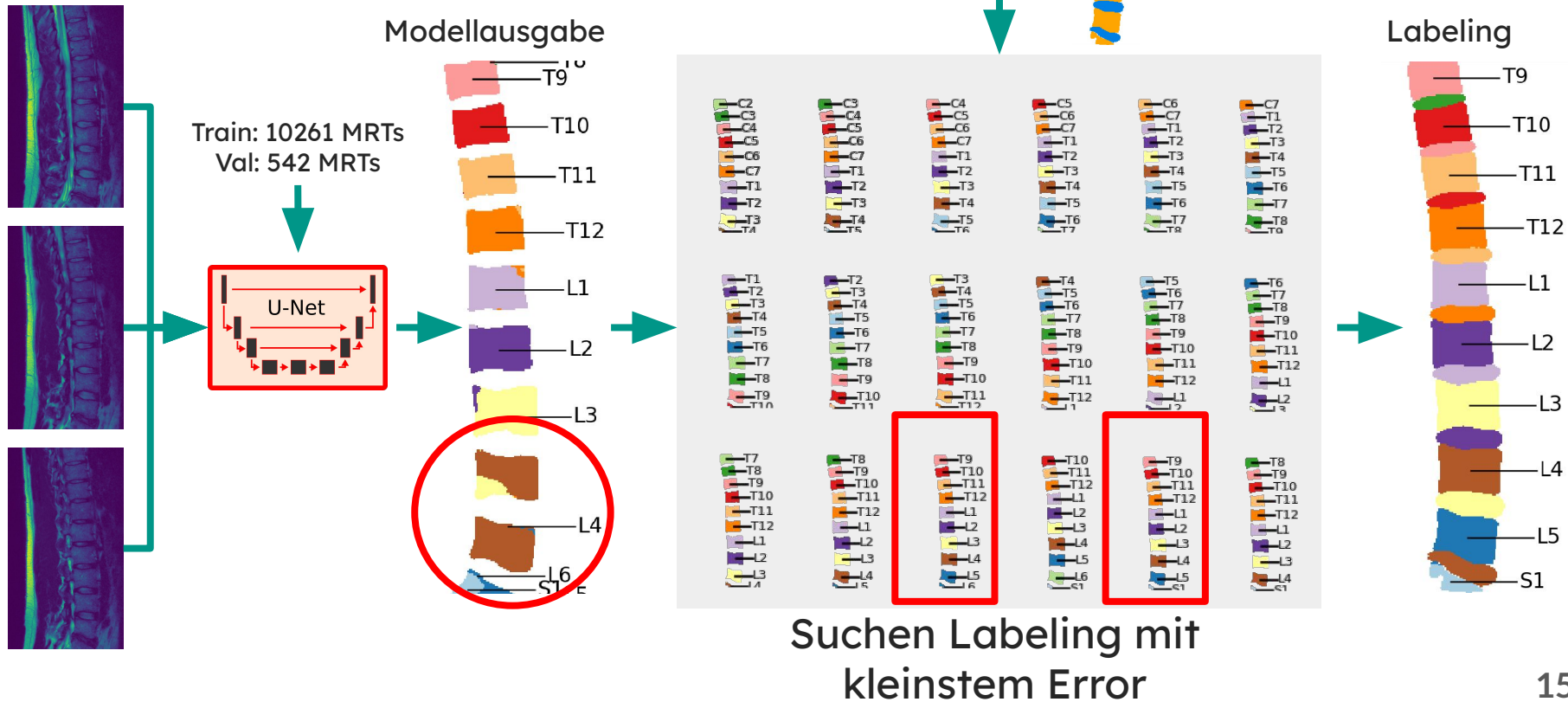
Labeling



Methoden für Ausschnitt-Labeling



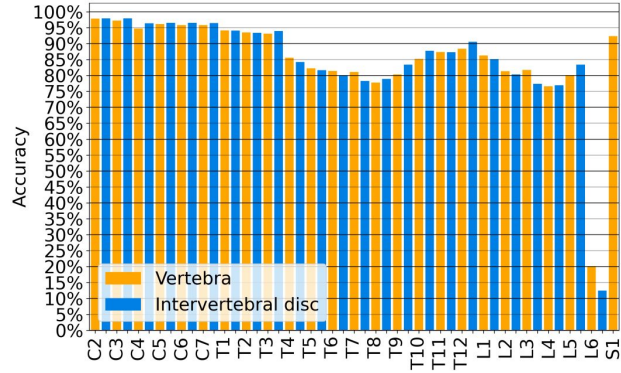
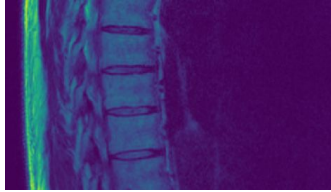
MRT-Ausschnitt Labeling mittels Segmentierungsansatz



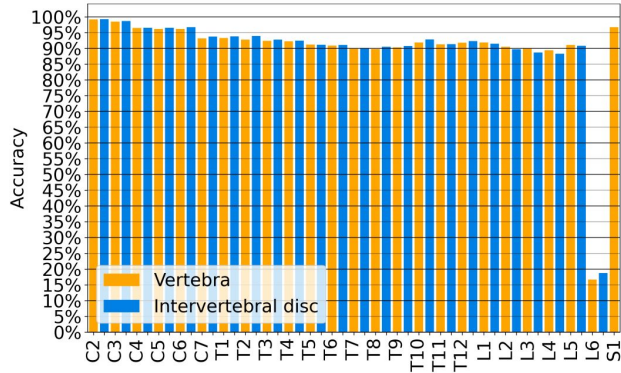
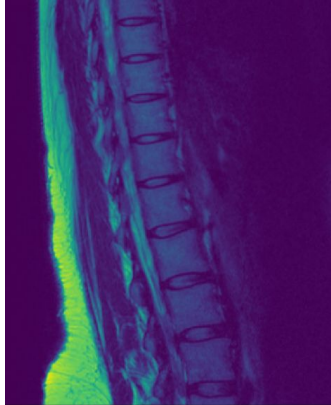
Auswertung MRT-Ausschnitt Labeling

Vergleich verschiedener Ausschnittgrößen

5 Wirbelkörper



10 Wirbelkörper



Ähnliche Ergebnisse

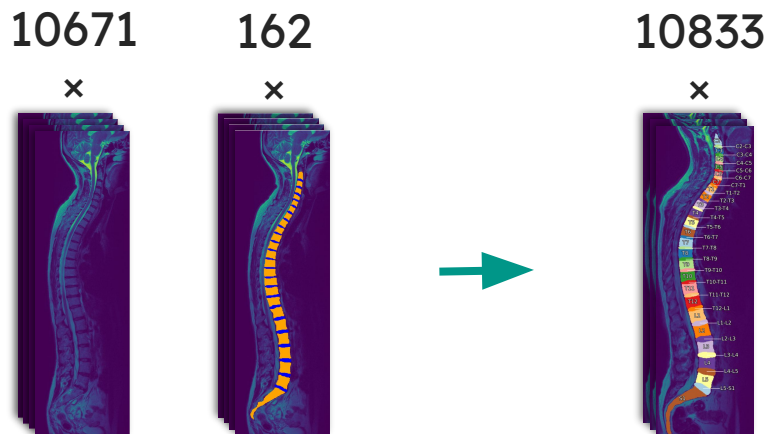
| Method | Dataset | FOV | Accuracy | DSC |
|-------------------------|-----------------------|-----------------------------|------------------|-------------------|
| Lessman et al. [36] | 15 CTs | $V \approx 18$ | 100% | 0.958 |
| | 35 low-dose chest CTs | $V \approx 12$ | 95.7% | 0.921 |
| Payer et al. [37] | VerSe19: 374 CTs | $V \in \{5, 6, \dots, 26\}$ | 95.0% | 0.904 |
| VerteFormer [54] | VerSe19: 374 CTs | $V \in \{5, 6, \dots, 26\}$ | - | 0.865 |
| | VerSe20: 300 CTs | $V \in \{5, 6, \dots, 26\}$ | - | 0.869 |
| Spine-transformers [55] | VerSe19: 374 CTs | $V \in \{5, 6, \dots, 26\}$ | 96.7% | 0.901 |
| SpineParseNet [17] | 215 lumbar MRIs | $V \approx 8$ | - | 0.875 ± 0.038 |
| Spine-GAN [56] | 253 lumbar MRIs | $V \approx 8$ | - | 0.870 ± 0.010 |
| Chang et al. [53] | 292 T10 to S1 MRIs | $V \in \{6, 7, 8, 9\}$ | $89.3\% \pm 5.2$ | 0.871 ± 0.041 |
| Ours | 10,833 complete MRIs | $V = 5$ | 85.5% | 0.799 |
| | | $V = 8$ | 90.9% | 0.839 |
| | | $V = 10$ | 92.6% | 0.847 |
| | | $V = 15$ | 94.4% | 0.875 |

Ausblick

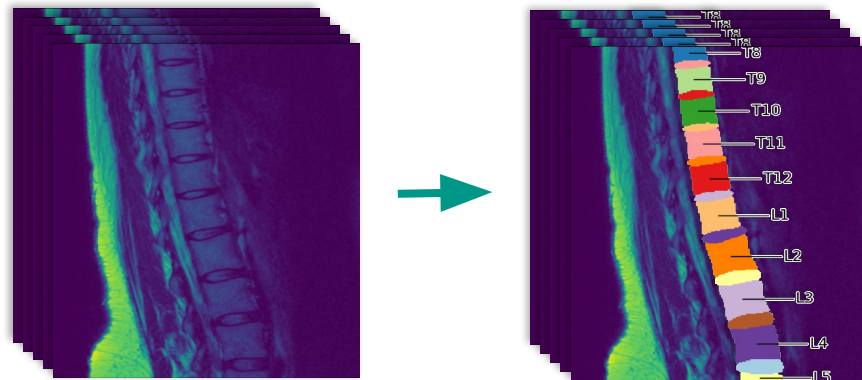
- Datensatz Vergrößerung von **10833** auf **≈30000**
- Evaluation auf anderen Datensätzen
- Analyse von Krankheiten mittels Segmentierung
- Unterstützung von Radiologen durch Segmentierung

Zusammenfassung

Labeling-Pipeline von **vollständigen MRTs**



Labeling-Pipeline von **MRT-Ausschnitten**



Vielen Dank für Ihre Aufmerksamkeit!

Source Code:

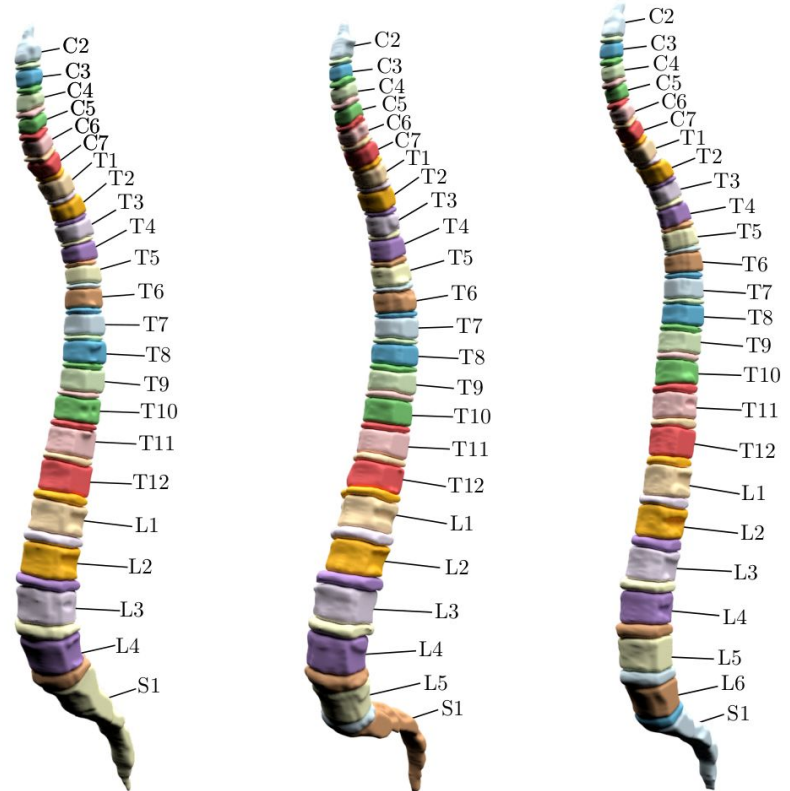
<https://github.com/LiquidFun/Spine>

Folien:

<https://brutenis.net/master-thesis-slides>

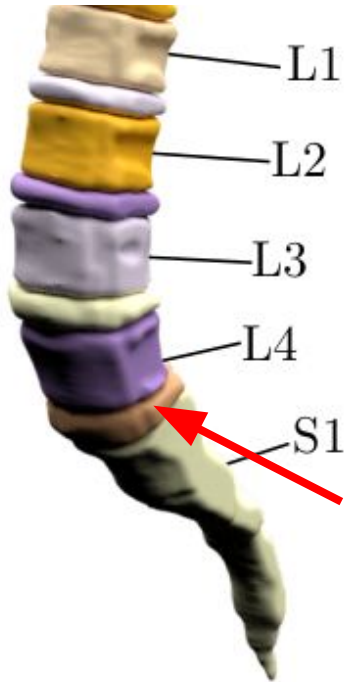
Masterarbeit:

<https://brutenis.net/master-thesis>



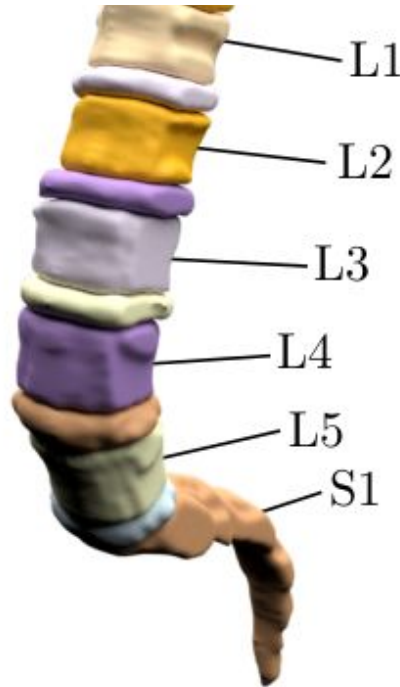
Sakralisierung und Lumbarisierung

Sakralisierung
393/10833 ($\approx 3.6\%$)

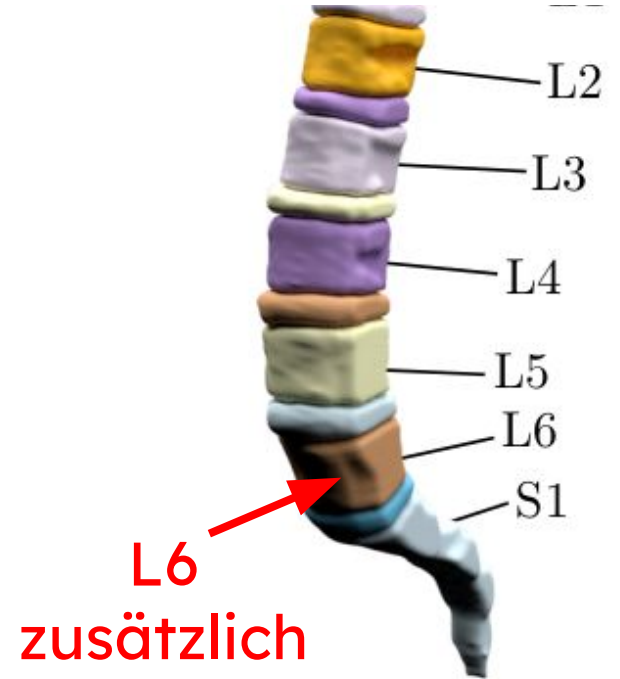


L5 fehlt

Normal
9730/10833 ($\approx 90\%$)



Lumbarisierung
710/10833 ($\approx 6.6\%$)

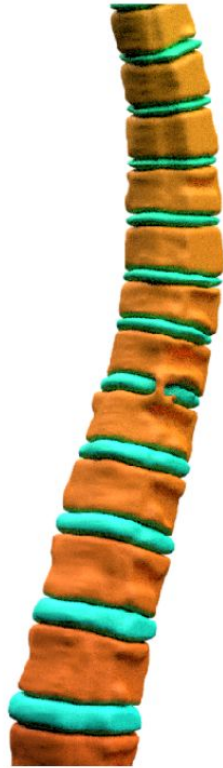
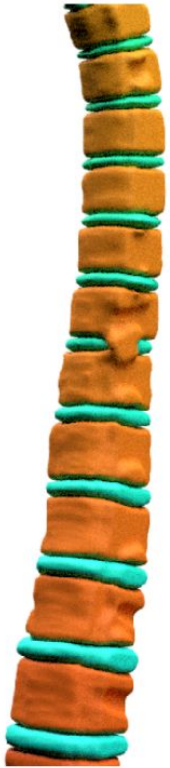


L6
zusätzlich

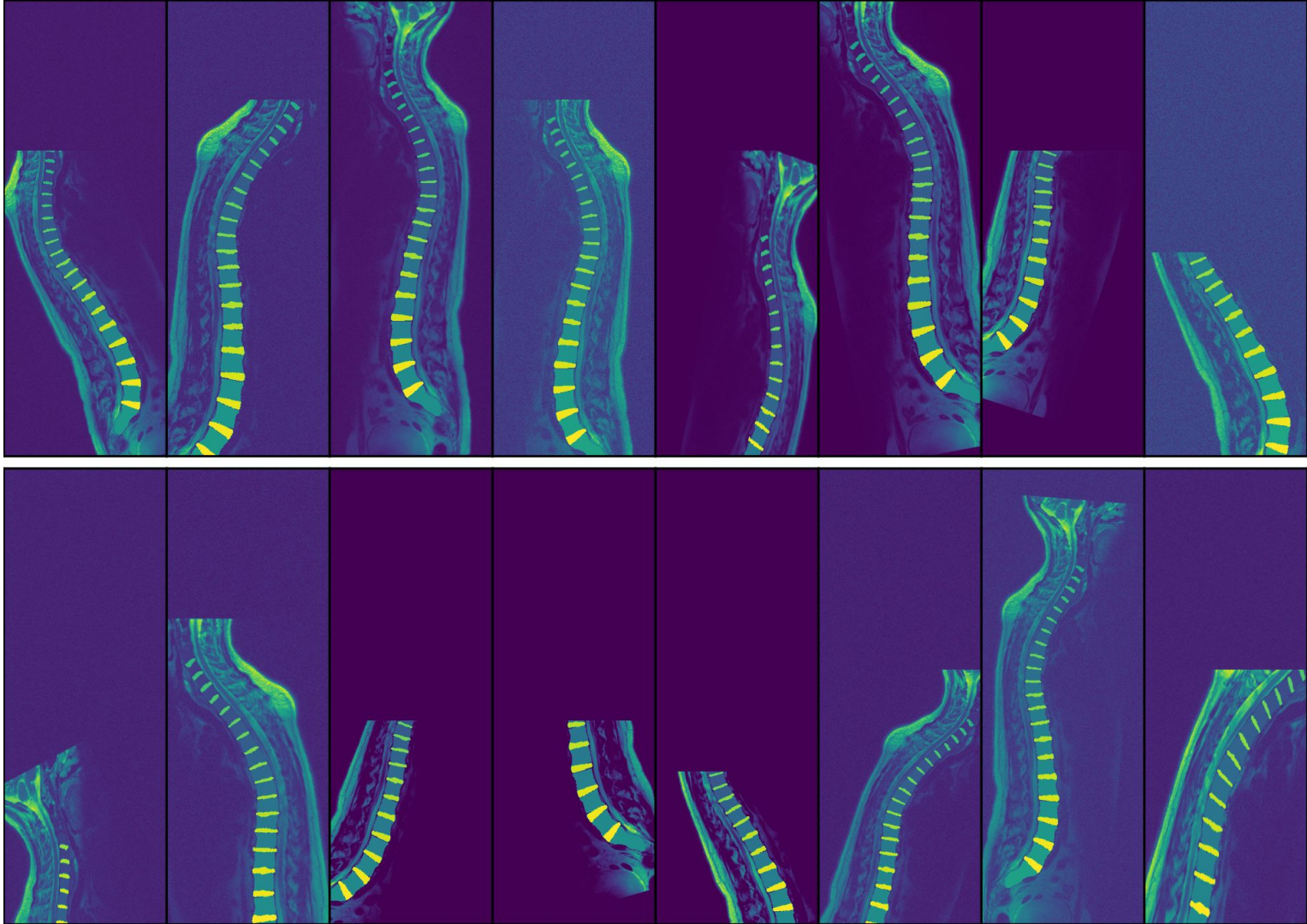
Segmentation Preprocessing



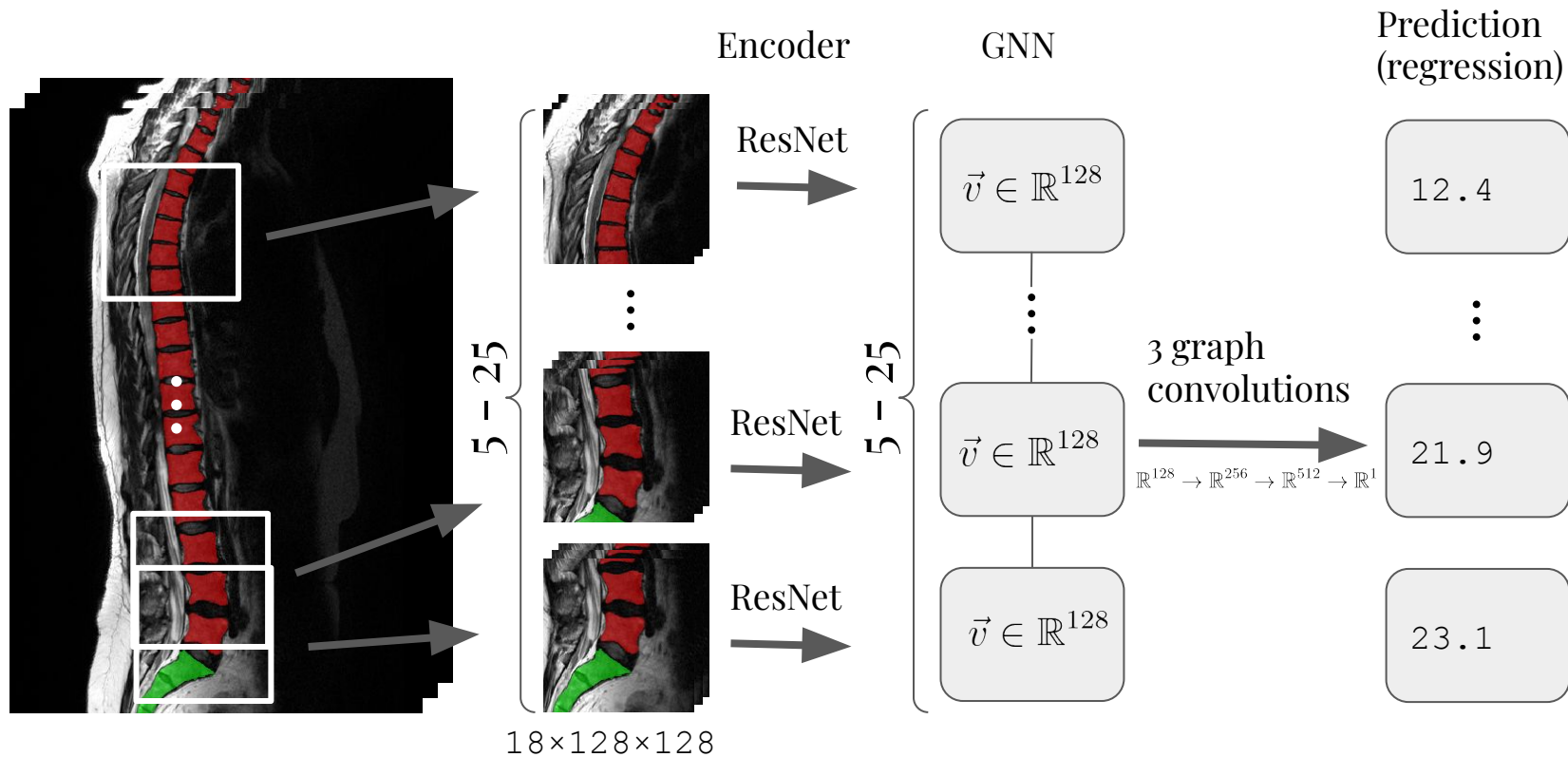
Warum Ebenen zum splitten?



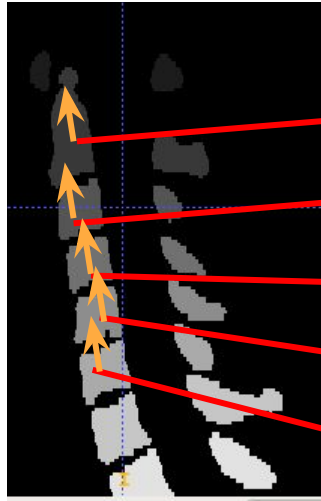
Augmen- tations



Encoder + GNN



Vector-based classification



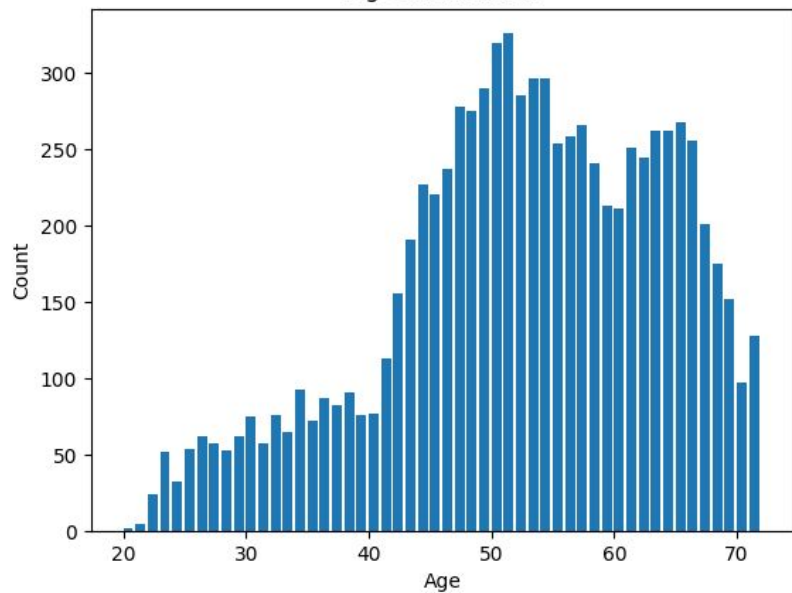
| roi | x | y | z |
|-----|-----|----|----|
| C2 | .2 | .4 | .2 |
| C3 | .4 | .3 | .7 |
| C4 | ... | | |
| C5 | | | |
| C6 | | | |
| ... | | | |
| S1 | | | |

10000
patienten

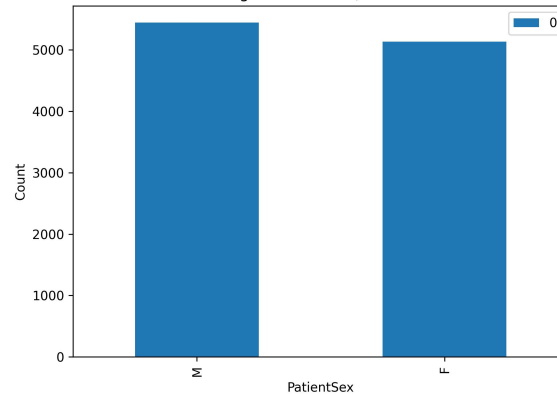
| roi | x | y | z |
|-----|-----|----|-----|
| ? | .1 | .2 | .7 |
| ? | .4 | .3 | .47 |
| ? | ... | | |
| ? | | | |
| ? | | | |

Metadata

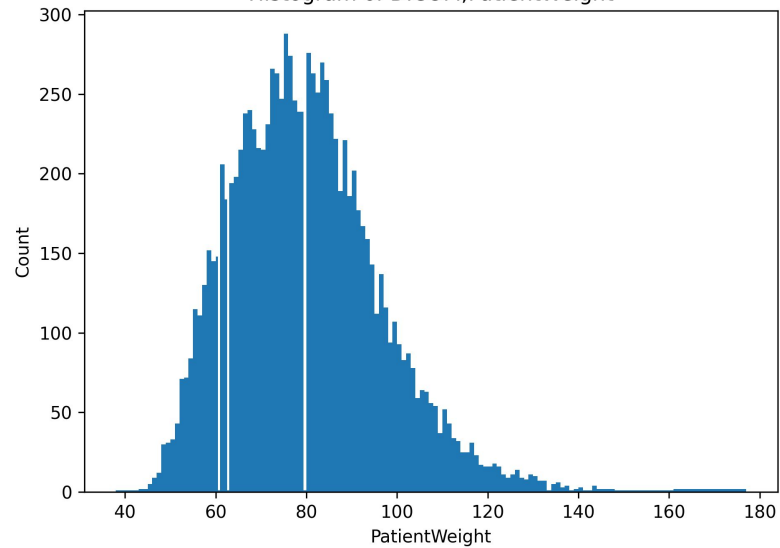
Age distribution

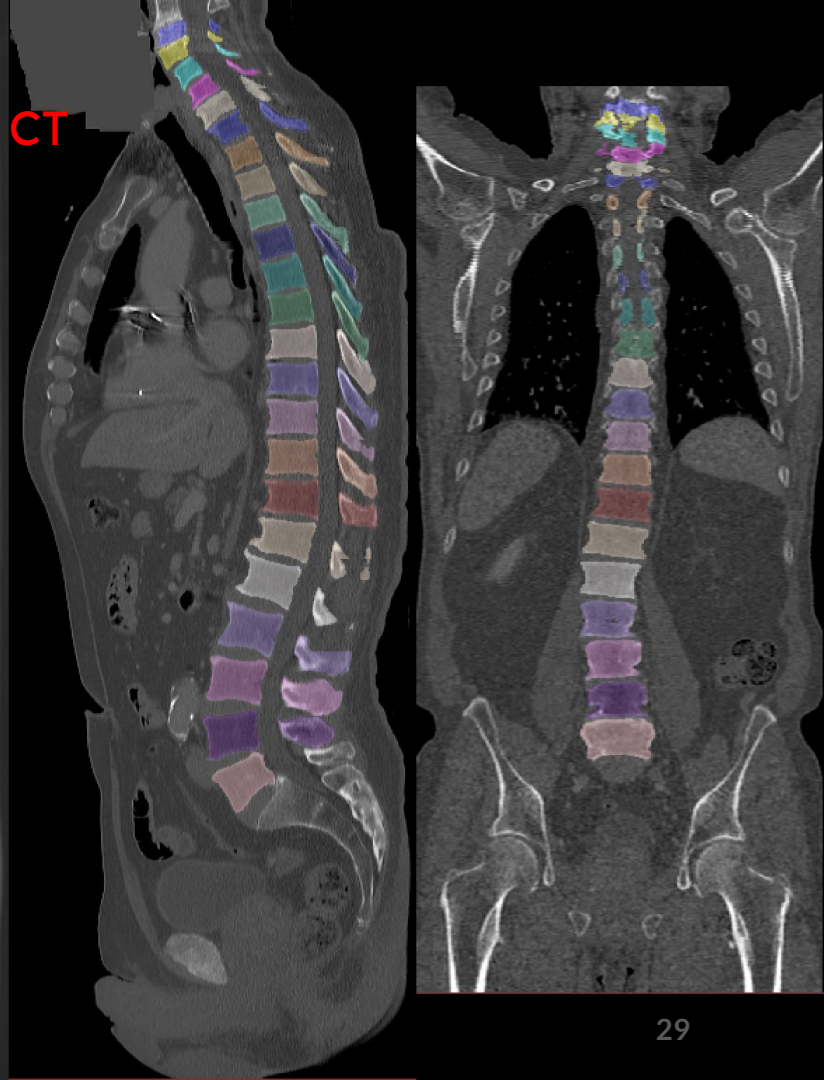
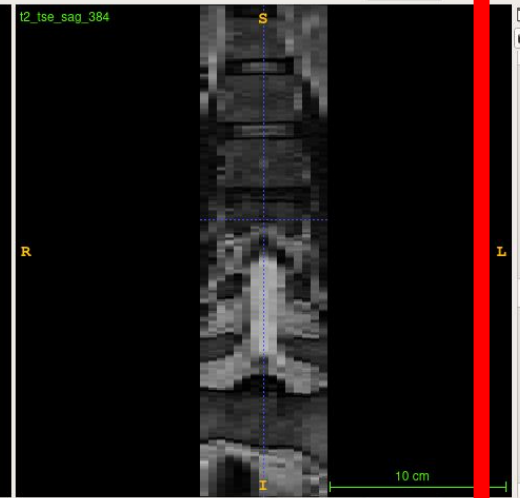
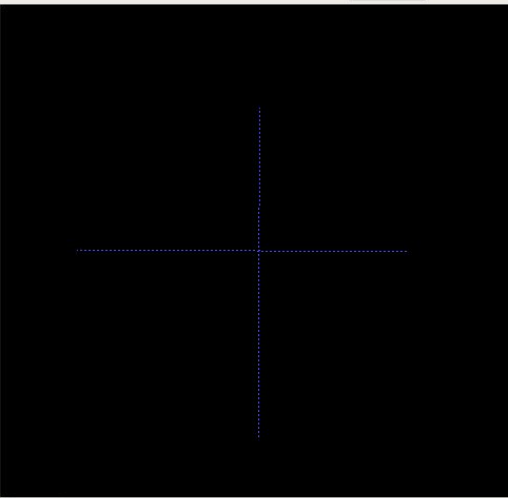
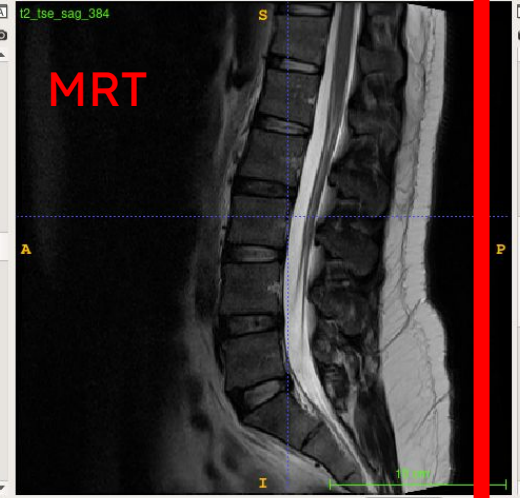
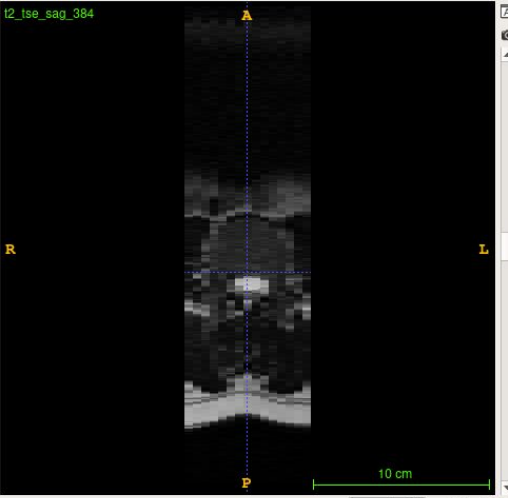


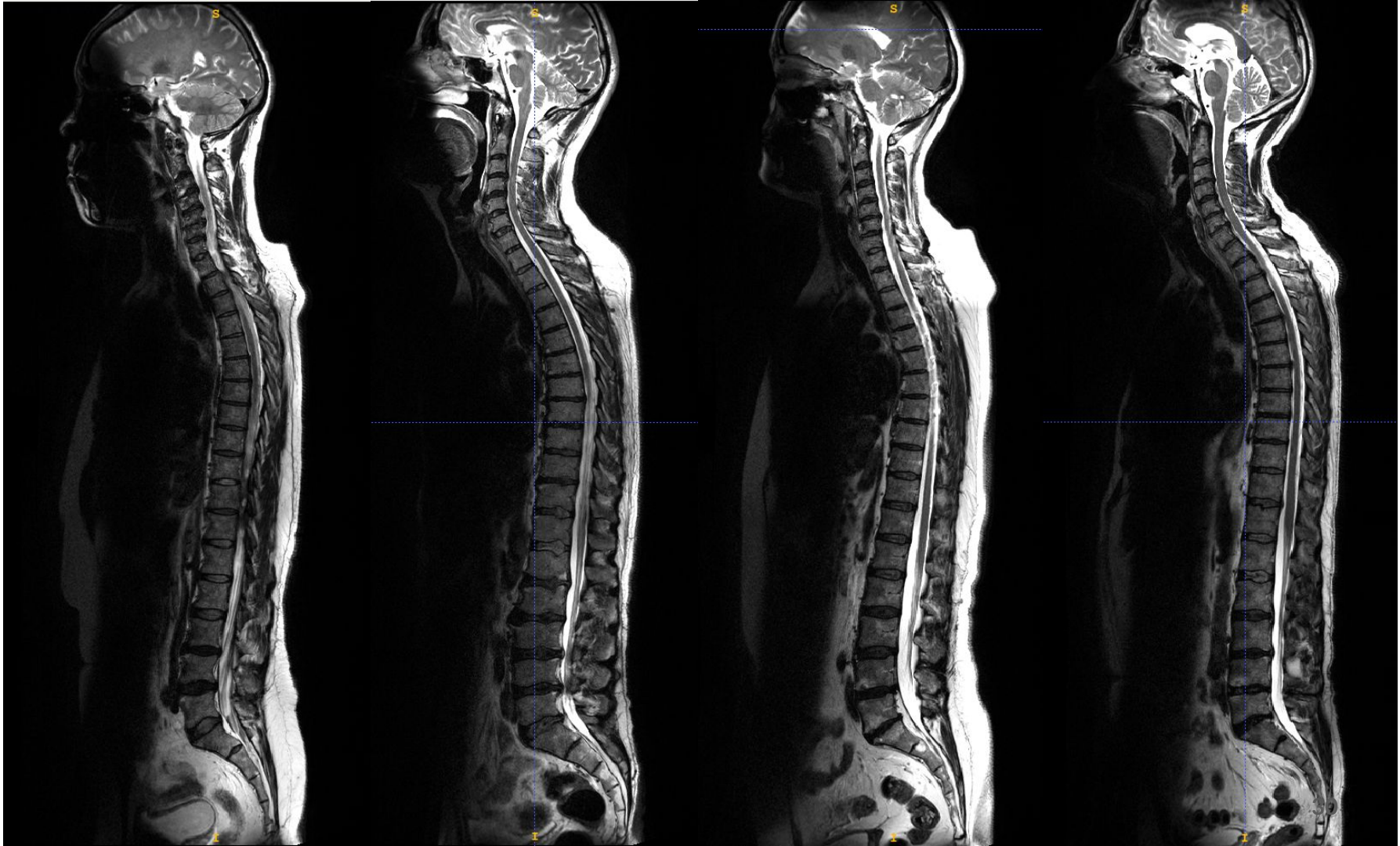
Histogram of DICOM;PatientSex

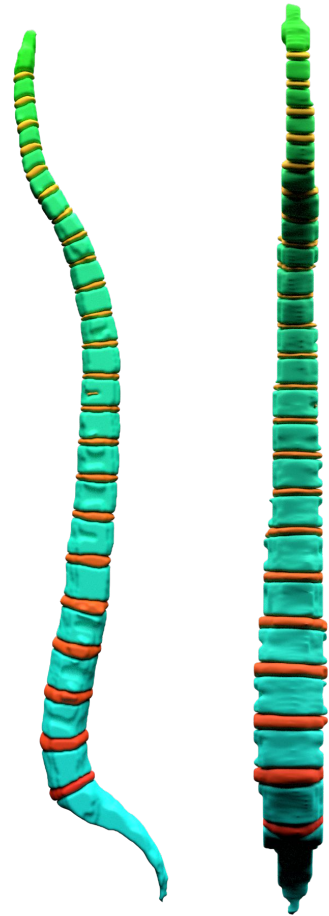
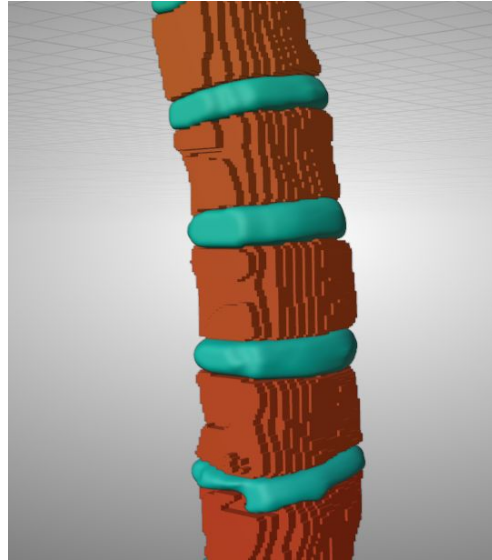
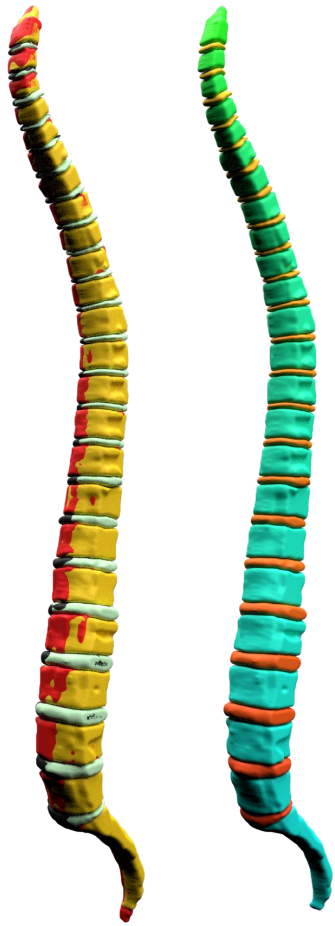


Histogram of DICOM;PatientWeight

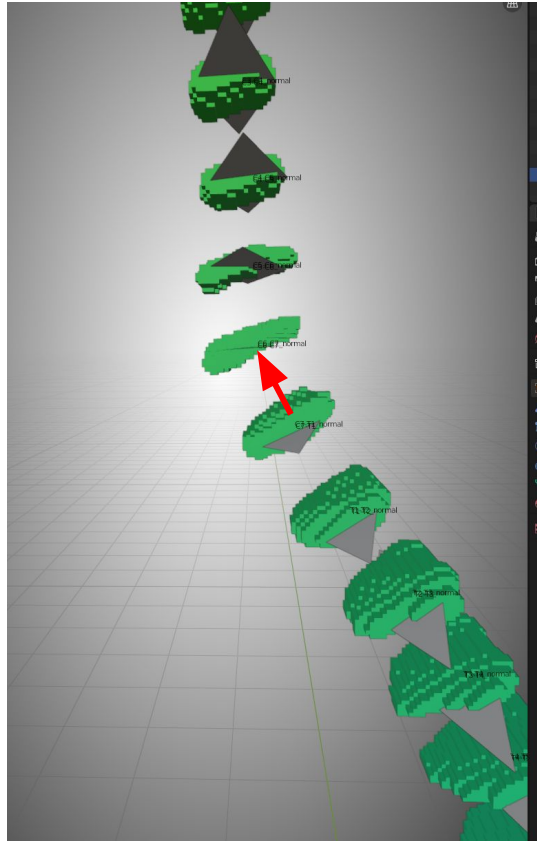




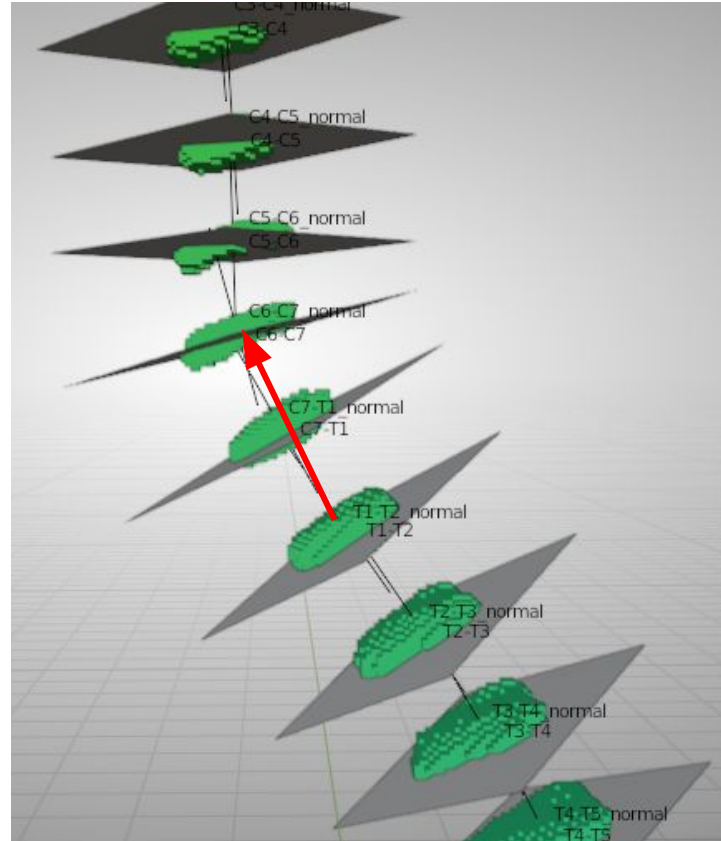




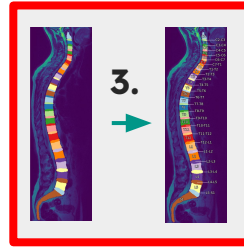
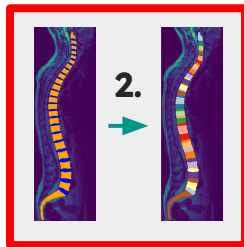
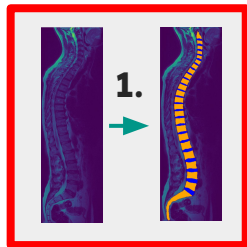
normal is diff between
curr and adjacent



normal is diff between
lower and upper

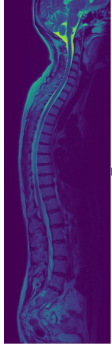


Nicht benutzt



Skip

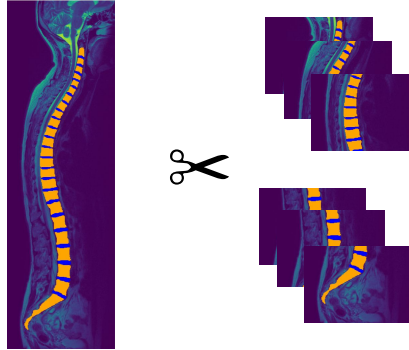
10671 ×



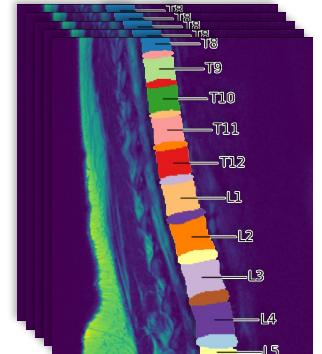
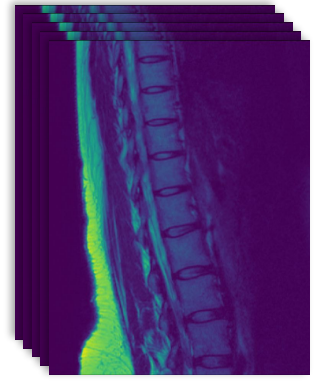
162 ×



- 1. Bemerkung



- 2. Bemerkung: Sehr viele Daten, aber wenig annotiert
- Nutzung aller Daten ermöglicht:
 - Verschiedene Modelle
 - Training besserer Modelle
 - Erhebung von Statistiken
 - Mehr validierungsdaten

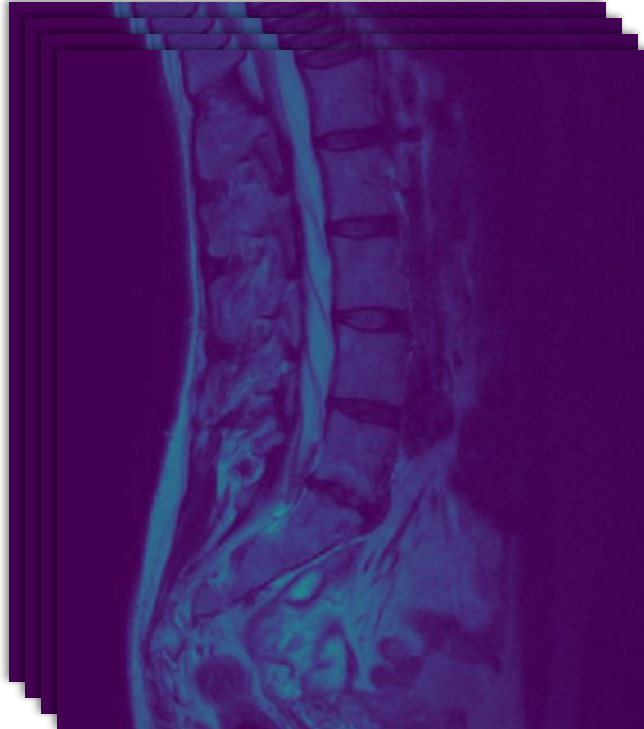


Motivation: Warum “Small Field of View”?

Scout
<1 min



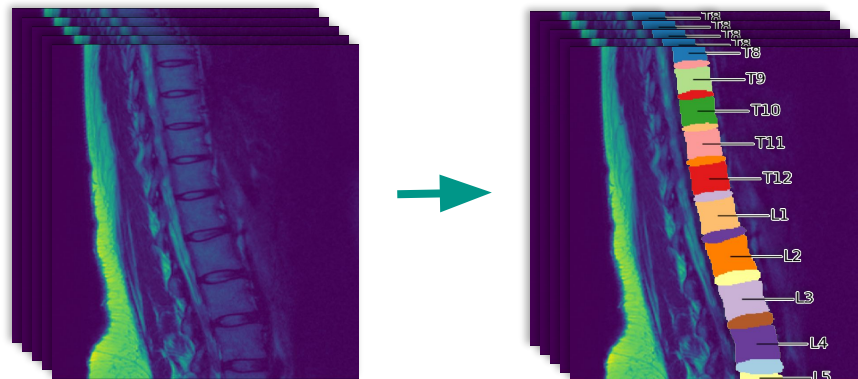
Small FOV MRT
30-90 min



- Ärzte/Radiologen zählen von oben um Wirbel zu bestimmen
- Mittels Algorithmus realisierbar
- Jedoch: Scouts werden fast nie in Datensätzen veröffentlicht

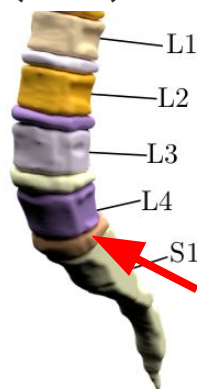
Zusammenfassung (skip)

- Pipeline zur Segmentierung von “Small Field of View” MRTs



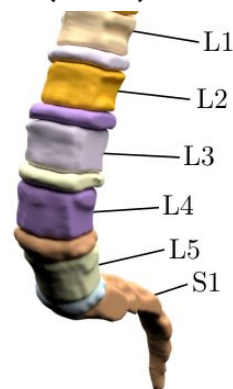
- Sakralisierung und Lumbarisierung

Sakralisierung
(≈3.6%)

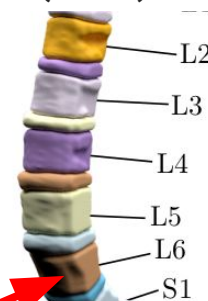


L5 fehlt

Normal
(≈90%)

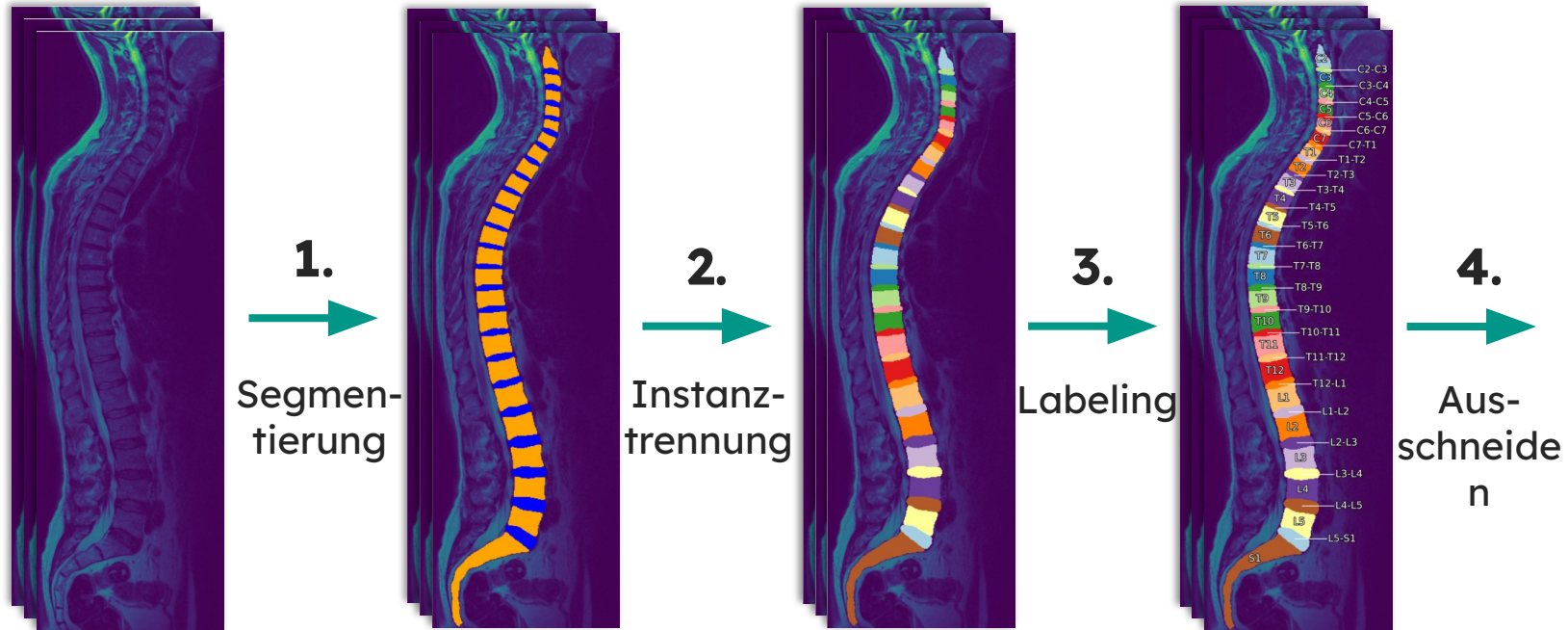


Lumbarisierung
(≈6.6%)

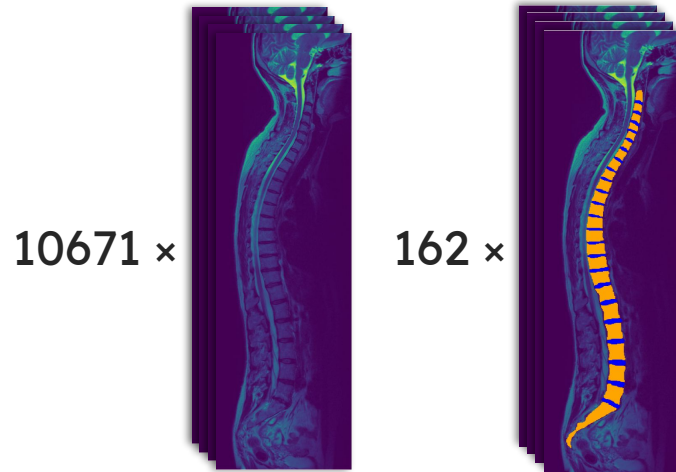


L6 zusätzlich

Pipeline für vollständige MRTs



4. Ausschneiden



Nutzung aller Daten ermöglicht:

- Verschiedene Modellansätze
- Training besserer Modelle
- Erhebung von Statistiken
- Mehr Validierungsdaten

