Modeling the acquisition shift between axial and sagittal MRI for diffusion superresolution to enable axial spine segmentation

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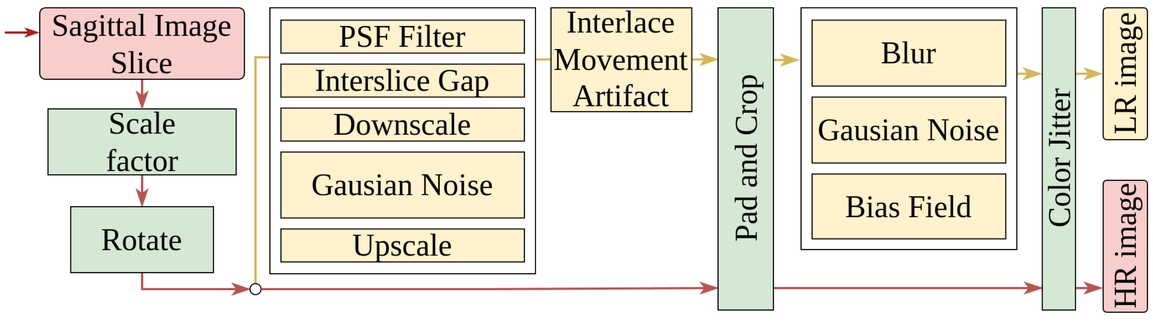
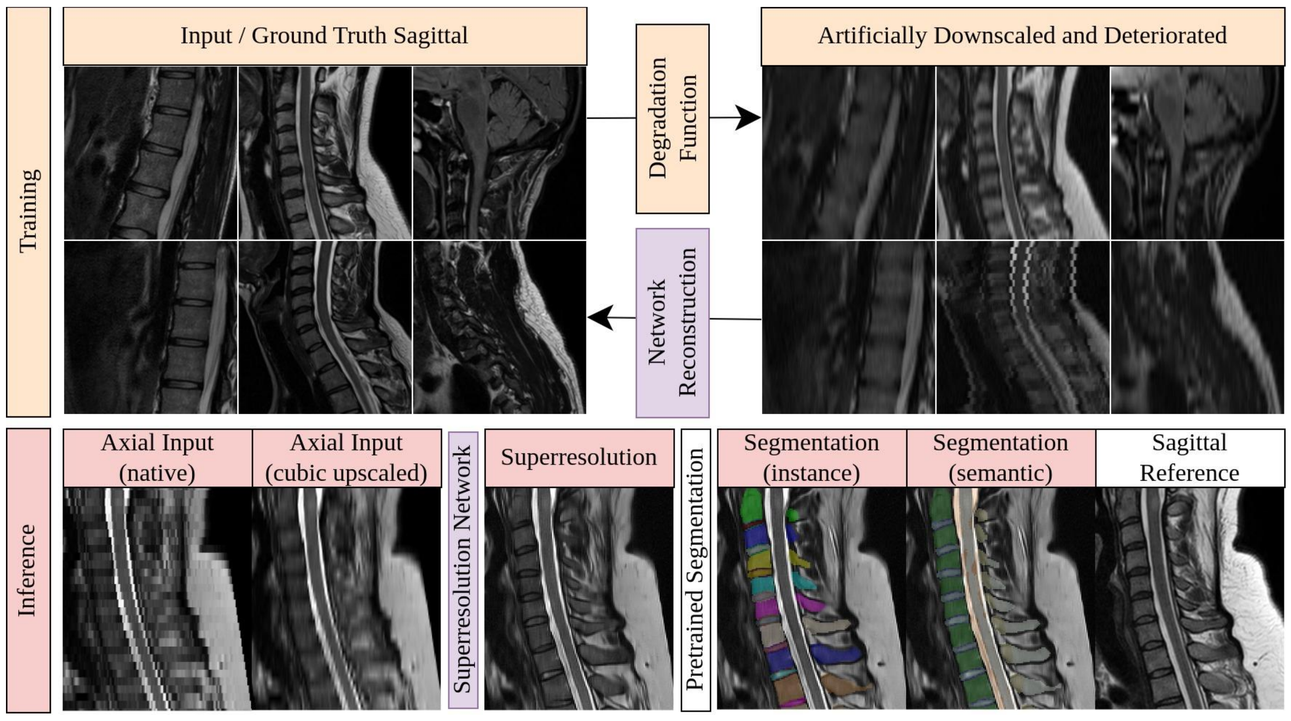
Method

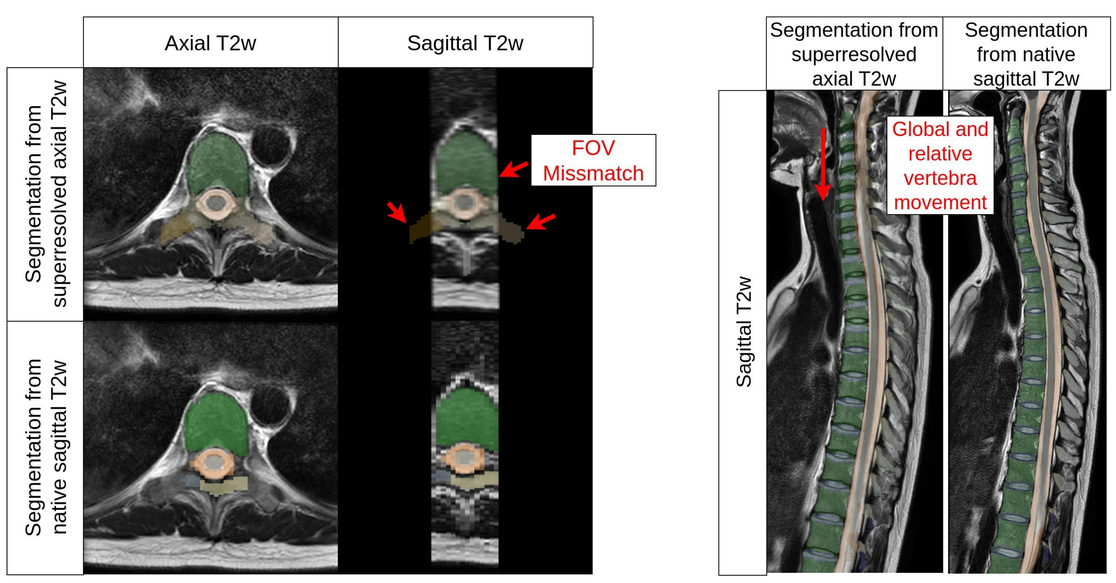
- Unpaired, off-axis inpainting superresolution remains under explored.
- For simulation of axial images, realistic rescaling of sagittal images require a specific degradation function.
- No vertebra height labeling available for axial images. This is required for spinal cord template registration.
- **Our pipeline:**





Problem Statement – Spinal Cord Registration

- General deformable spine image registration does not exist.
- Even rigid registration is challenging when the partial volume effect is too large, like in our 5 mm axial acquisitions.
- Commonly, sagittal and axial images do not share the same field of view and may have movement between acquisitions.
- Aligning spinal cords from different scan sessions needs strong supervision with points of interest and segmentation labels.



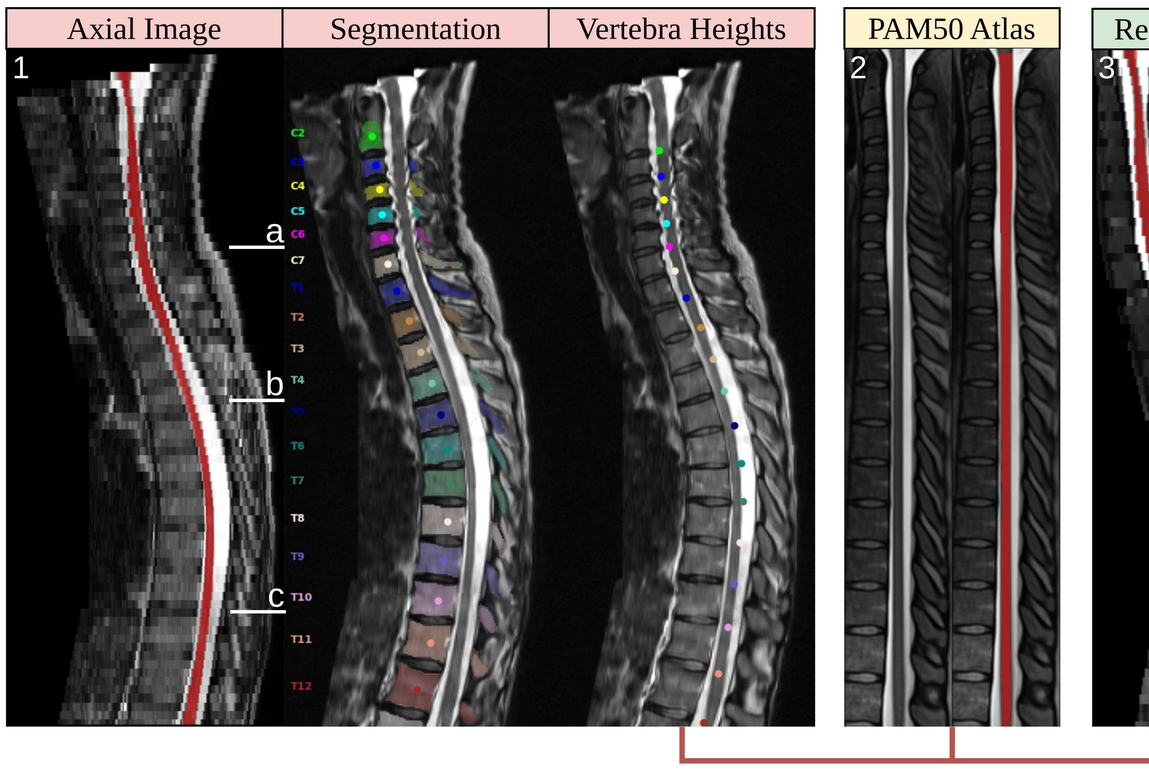
Experiments

- We compare our diffusion-based algorithm with degradation modeling against common benchmarks.
- Our conditional denoising diffusion outperforms large state-of-the-art superresolution models.

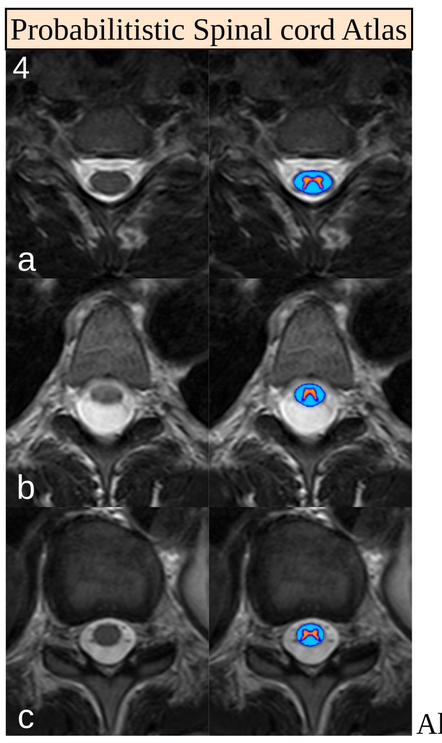
Vertebra	dtr↑	Betti b_0 er↓	Betti b_1 er↓	axial Dice↑
cubic interpolation	0.6464	0.435	0.600	0.684
ESRGAN (RRDBNet)	0.9224	0.141	0.318	0.695
HAT 4×4 blocks	0.9805	0.098	0.240	0.681
RCAN	0.9853	0.062	0.165	0.711
Palette (diffusion, ours)	0.9942	0.045	0.115	0.718

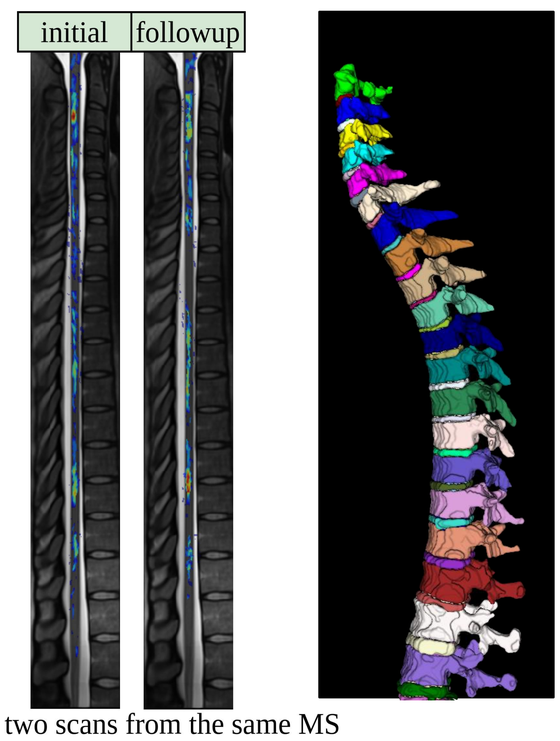
- Especially on large 5x scaling factors, standard superresolution algorithms drop in performance.
- Our degradation modeling improves individual downstream segmentations.
- In conclusion, our degradation enables informed inpainting of structures that are no longer visible or present in the axial image.

Our Superresolution enables Segmentation and Spinal Cord Registration for Axial Images.



Registering PAM50 onto the axial image





Aligning two scans from the same MS patient on different time points. MS Lesions are segmented with colors

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