Data augmentation for deep learning based accelerated MRI reconstruction with limited data

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ICML2021

Challenges of DL in medical imaging

- Deep learning models are extremely data-hungry

Google

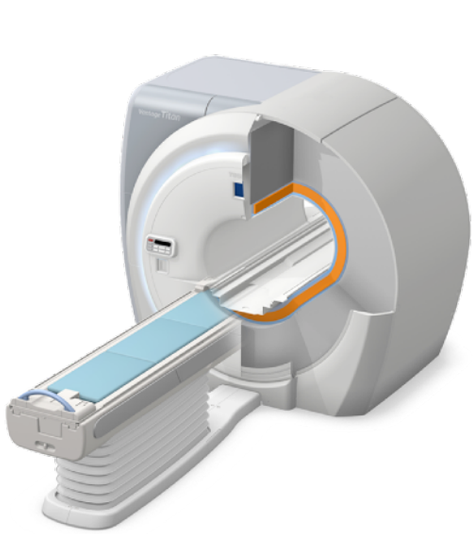
JFT-300M

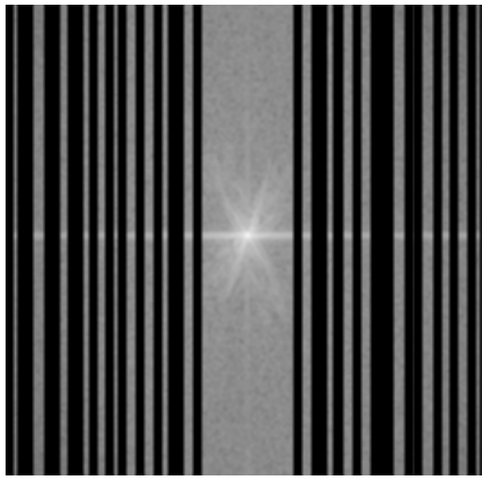
- Data collection for medical tasks is challenging:

1. **Cost**: expensive instruments, time of experts
2. **Time**: long acquisition time (MRI: 60 mins / scan)
3. **Health**: ionizing radiation exposure (CT, PET)
4. **Data curation**: patient confidentiality, data compatibility

How do we train with limited data?

MRI reconstruction

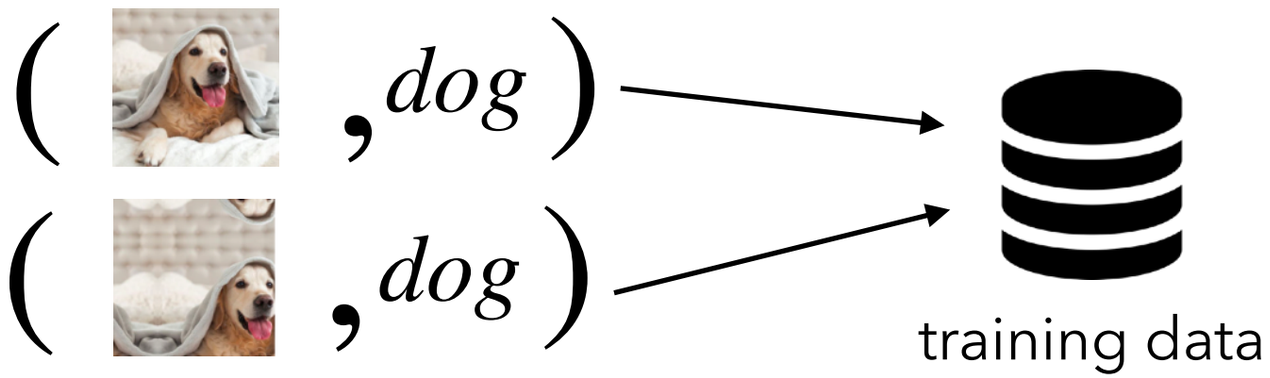




?

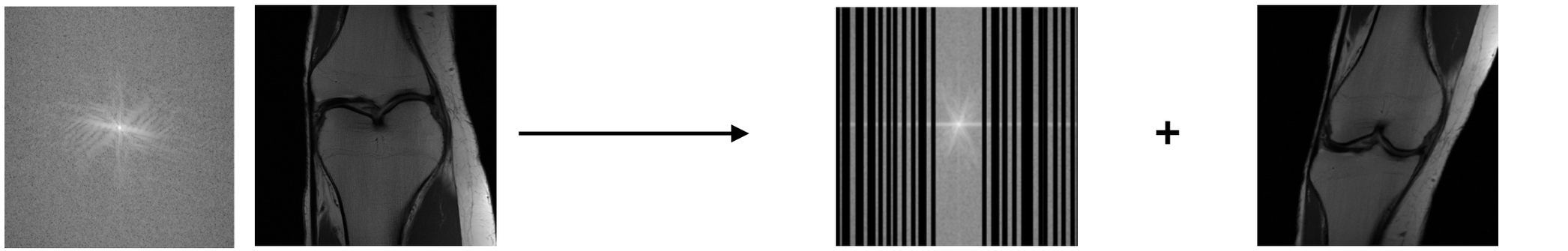
$\mathcal{F}$-transform + undersampling + noise

Data augmentation in classification: straightforward



Data augmentation in MRI reconstruction: non-trivial

1. Output is **not** invariant to transformations

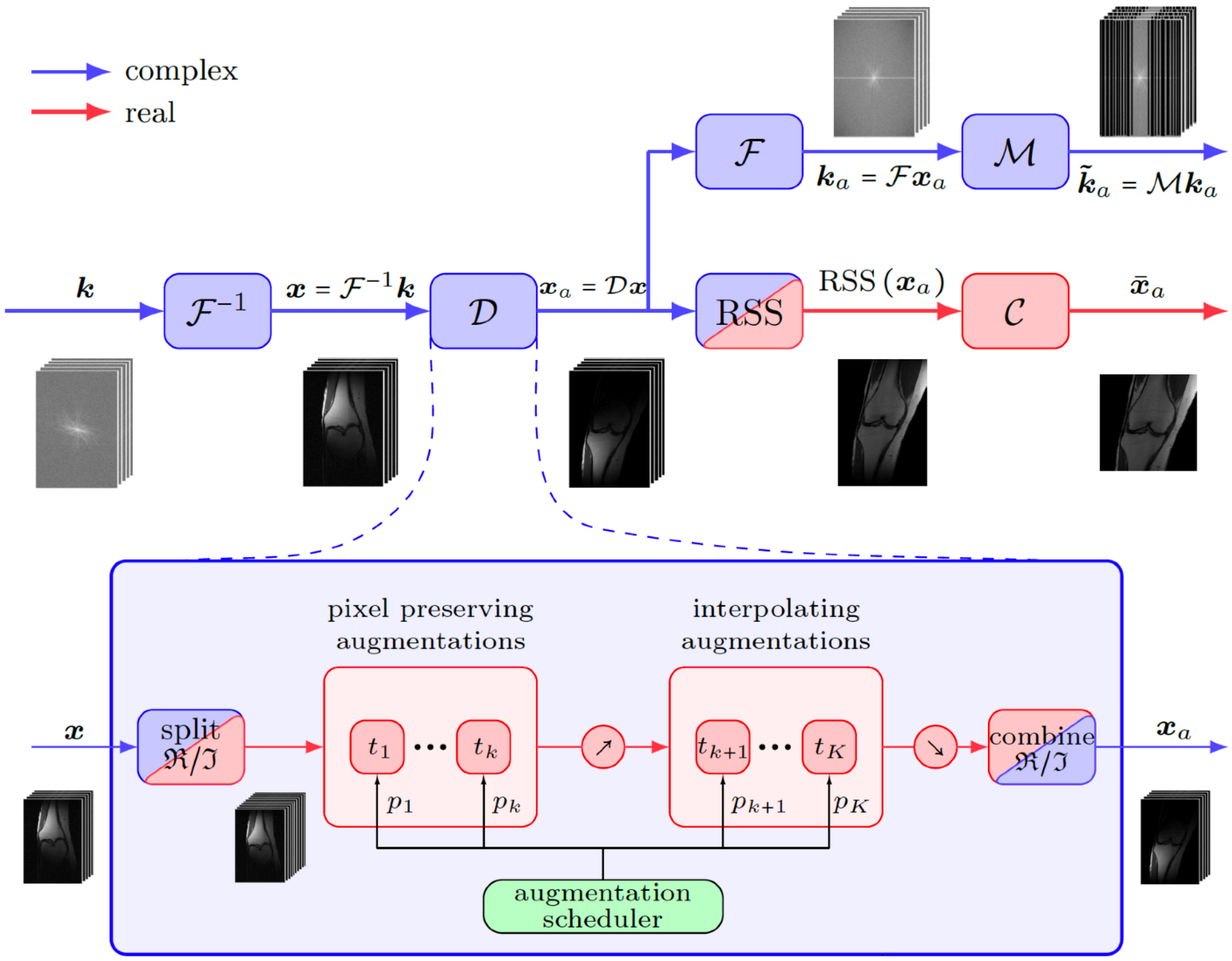


2. Distribution shift due to noise

$$x = x^* + n \longrightarrow x_{aug.} = \mathscr{D}x^* + \mathscr{D}n$$

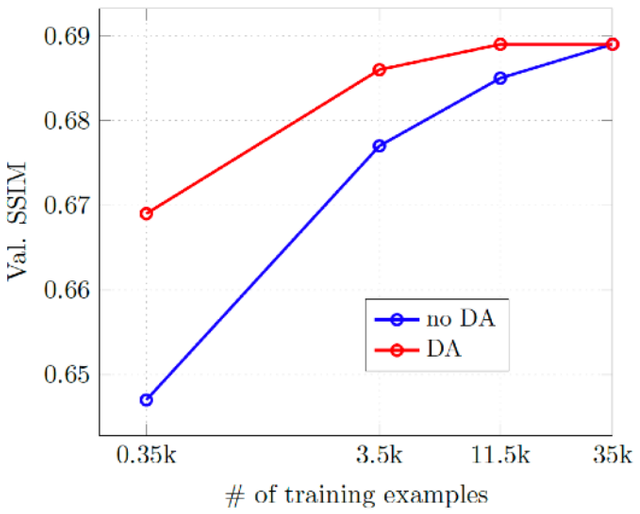
augmented signal — **augmented noise!**

MRAugment pipeline

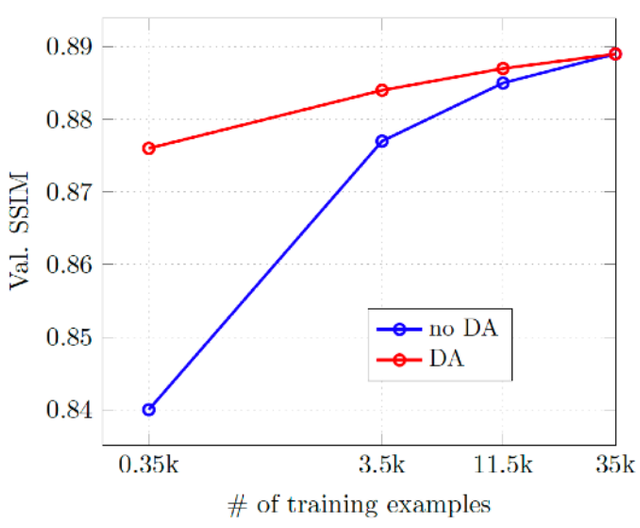


Results on various datasets

fastMRI knees

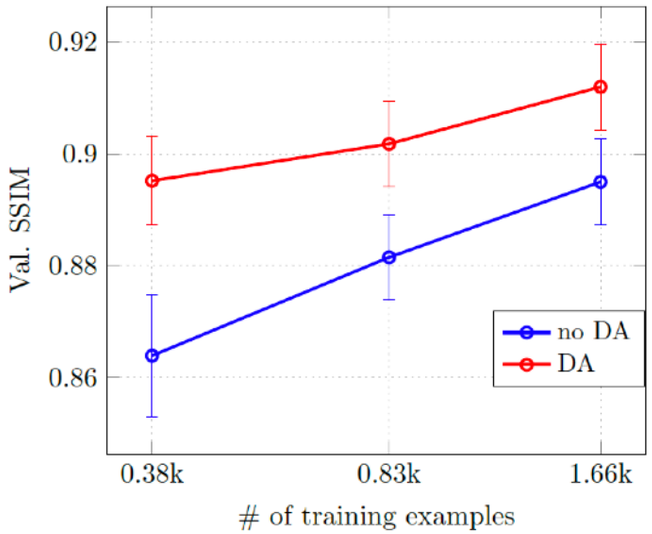


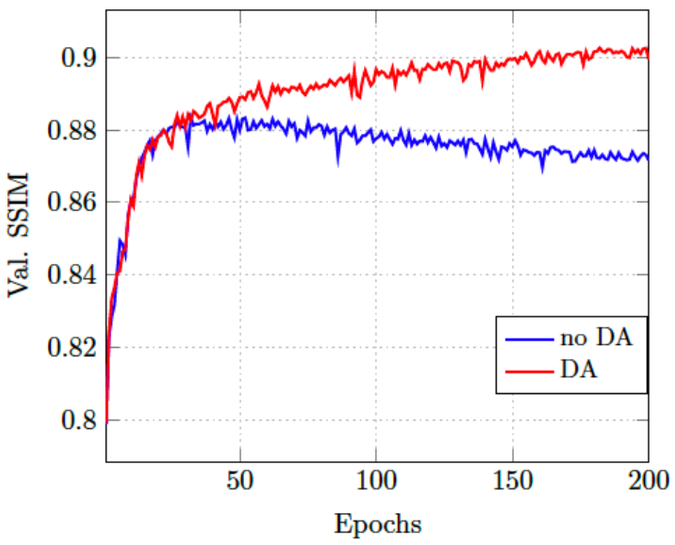
single-coil



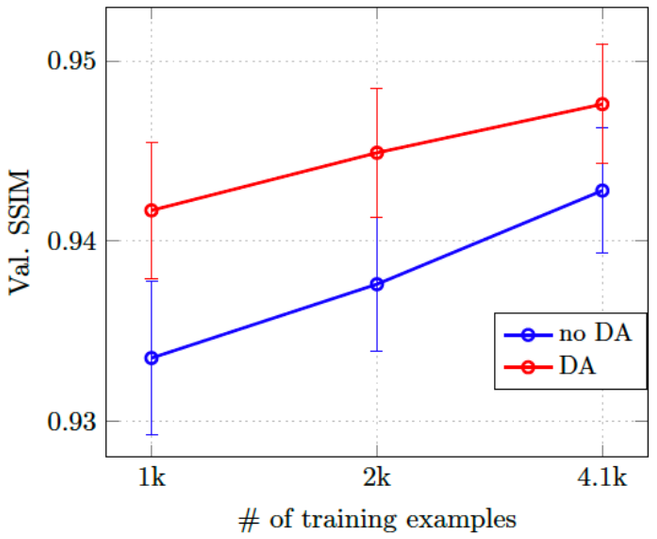
multi-coil

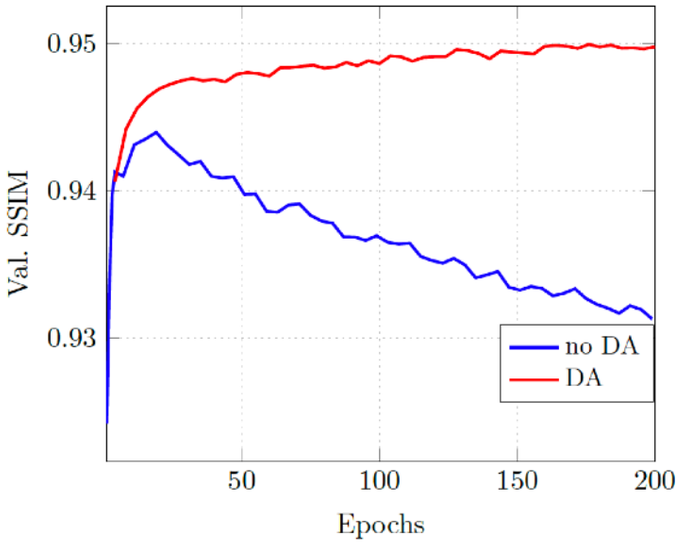
Stanford 2D FSE





Stanford 3D FSE knees





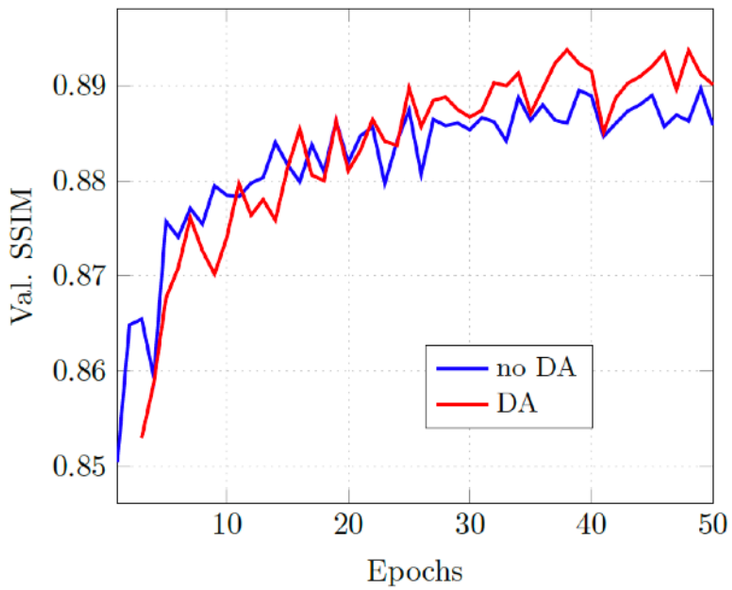
Robustness experiments

Unseen scanners

2% train	no DA	DA
$3T \rightarrow 3T$	0.8646	**0.9049**
$3T \rightarrow 1.5T$	0.8241	**0.8551**
$1.5T \rightarrow 3T$	0.8174	**0.8913**

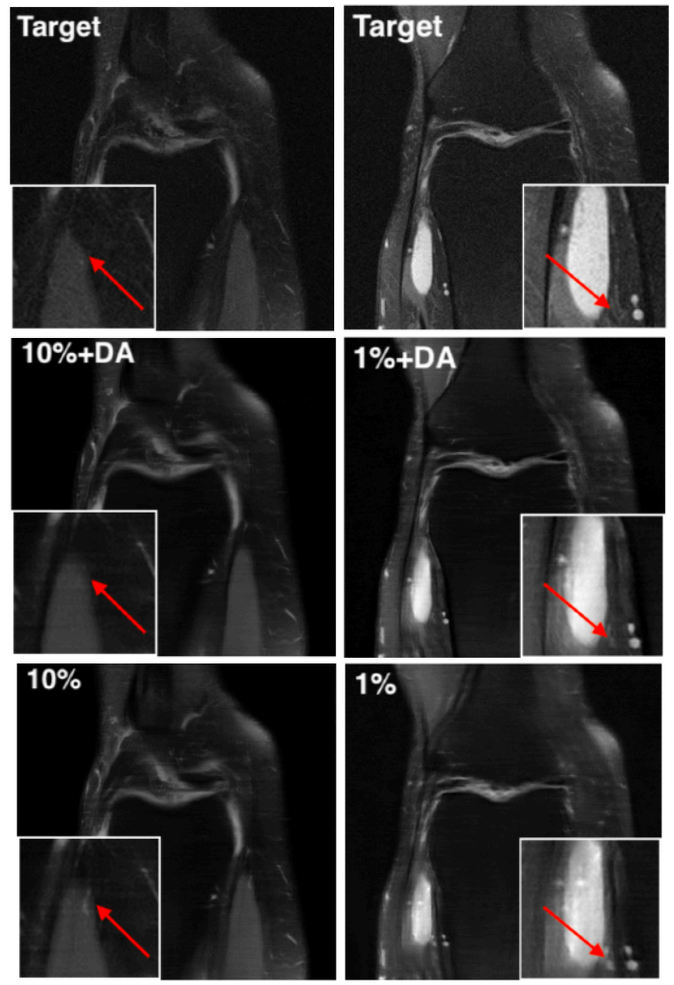
100% train	no DA	DA
$3T \rightarrow 3T$	0.9177	**0.9185**
$3T \rightarrow 1.5T$	0.8686	**0.8690**
$1.5T \rightarrow 3T$	0.9043	**0.9062**

Unseen anatomies



knee → brain

Hallucinations



MRAugment

https://github.com/MathFLDS/MRAugment