Super resolution accelerated MRI reconstruction using Deep learning

Subin Erattakulangara & Wahid Alam

May 1, 2022

Introduction

→ MRI as a medical imaging tool

- (+) Non-invasiveness and excellent soft-tissue contrast
- (-) Slow speed image acquisition: A bottleneck to real-time imaging
- (-)Spatiotemporal tradeoff
  - A compromise between spatial and temporal resolution

Problem

High fidelity MR images --> Low temporal resolution

- Large hardware setup
- Lengthy data acquisition--> subject motion

Low resolution images --> High temporal resolution

- hard to diagnose finer details
- Less number of pixels to characterize edges or boundaries
- Aliasing and noise

Proposed directions

✓Using MoDL for unfolding aliasing pattern and super-resolution

- *MoDL (Aggarwal et al., 2018)*

✓Implementing UF loss with MoDL for improving the super-resolution

- *Unsupervised Feature Loss (UFLoss) for High Fidelity Deep learning (DL)-based reconstruction (Wang et al., 2021)*

Using UF Loss

→ Inspired from perceptual loss from trained VGG

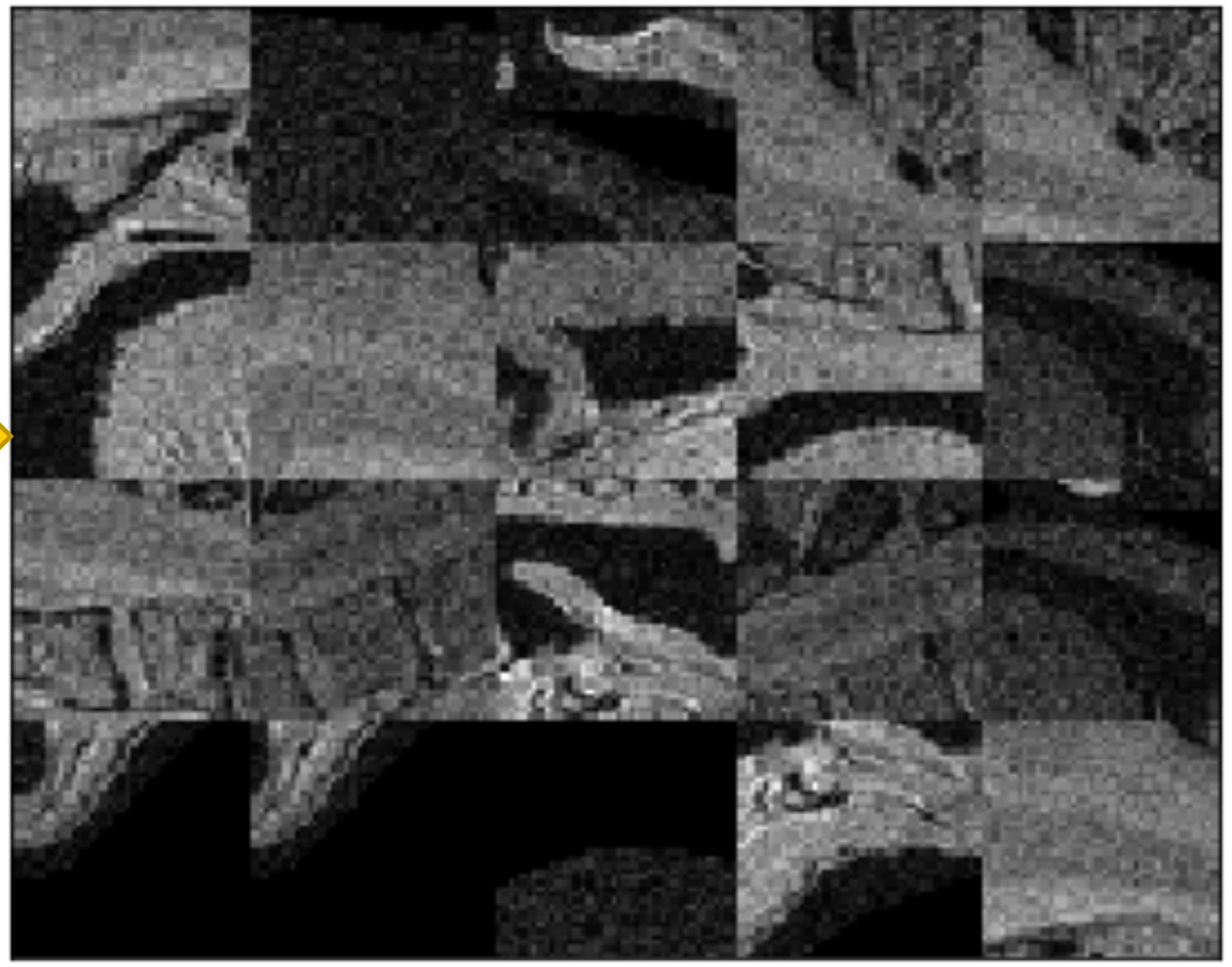
- *Ledig et al., 2017*

→ Perceptual loss from a training feature mapping network

- Encoder is trained with patches from the training sample

Results from UF loss

Training image sample

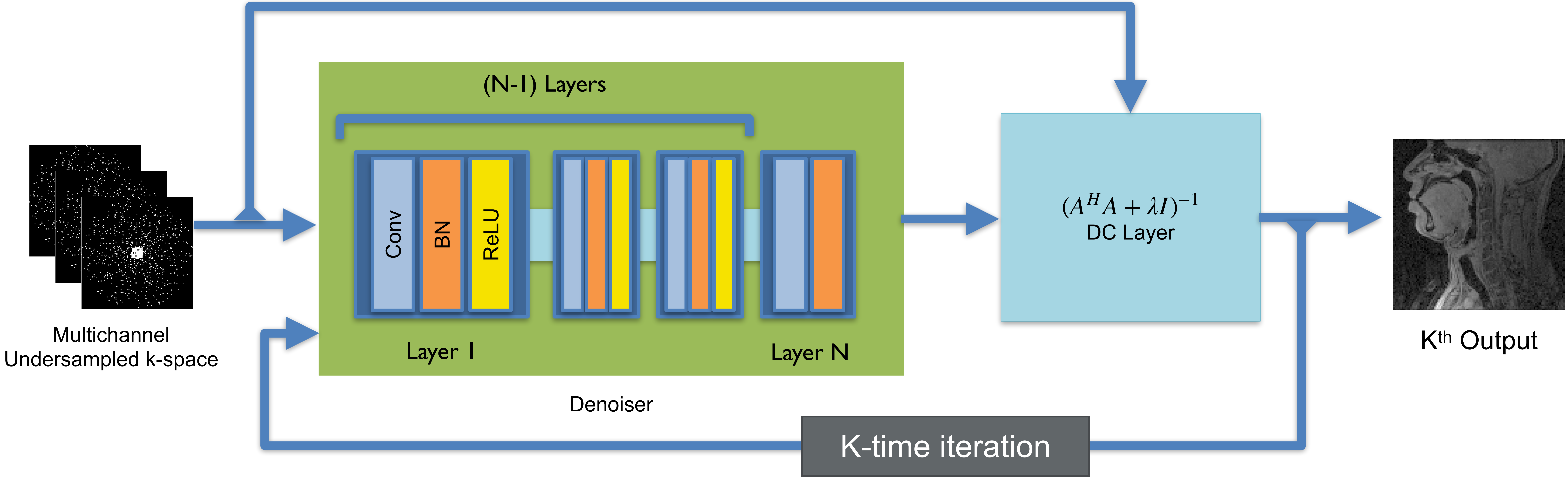


Training patches

Super resolution

MoDL

MoDL Network



H. K. Aggarwal et al., 2019

Dataset

Step 1: Data collection

- 5 subjects at 3T GE Premier scanner
  - [FOV: $24 \times 24 \times 24 \; cm^3$; $(k_x \;, k_y \;, k_z) = 128 \times 128 \times 32$; Flip angle: 5^o; Scan time: $20 \;\; secs$]
- Each subject was scanned with 3 different receive coils
- 15 Fully-sampled volumetric upper airway datasets
  - For training: (4x3=) 12 datasets (4 subjects)
  - For testing: (1x3=) 3 datasets (1 subjects)
- ESPIRiT coil maps from 5% of the center k-space

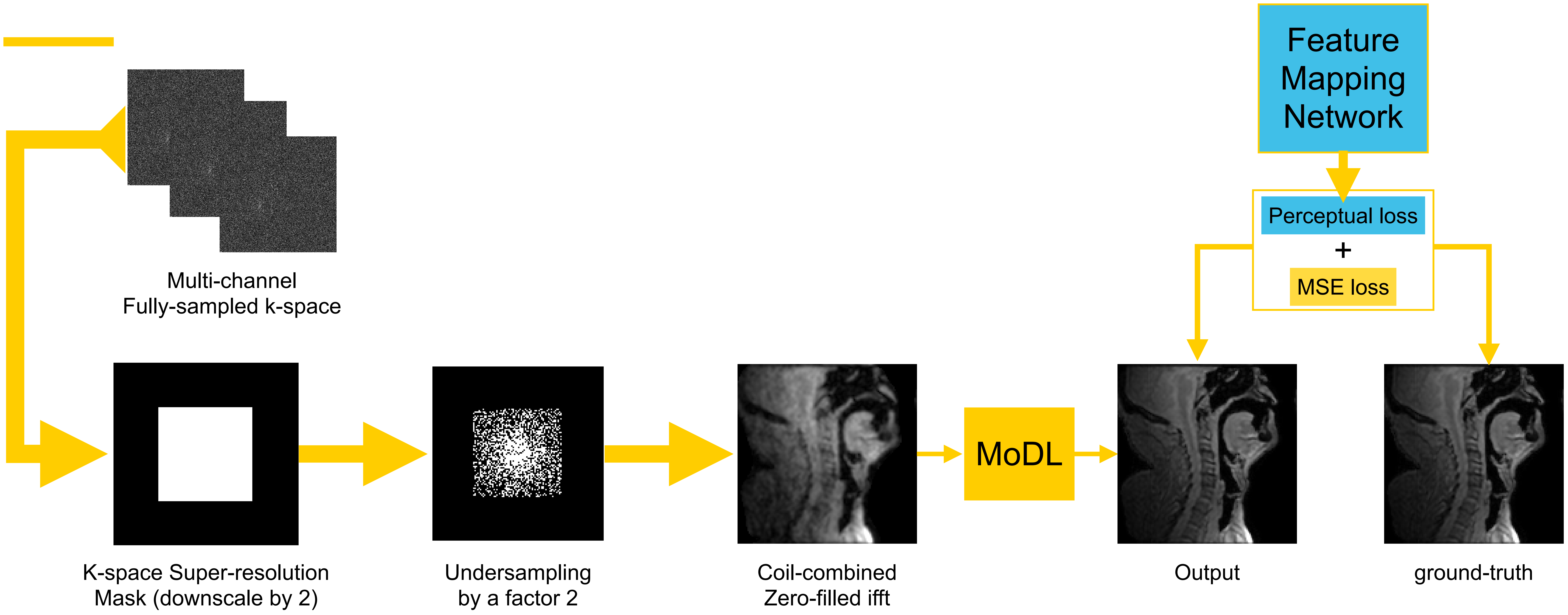
Phase 1: Data-preprocessing (in image domain)

→ Step 1: High-res ground truth (128x128) to Low res (64x64)
  - Maxpooling

→ Step 2: Undersampling by a factor of 4 in k-space

→ Step 3: train MoDL to learn the aliasing and noise pattern

Phase 2: Data-preprocessing in k-space

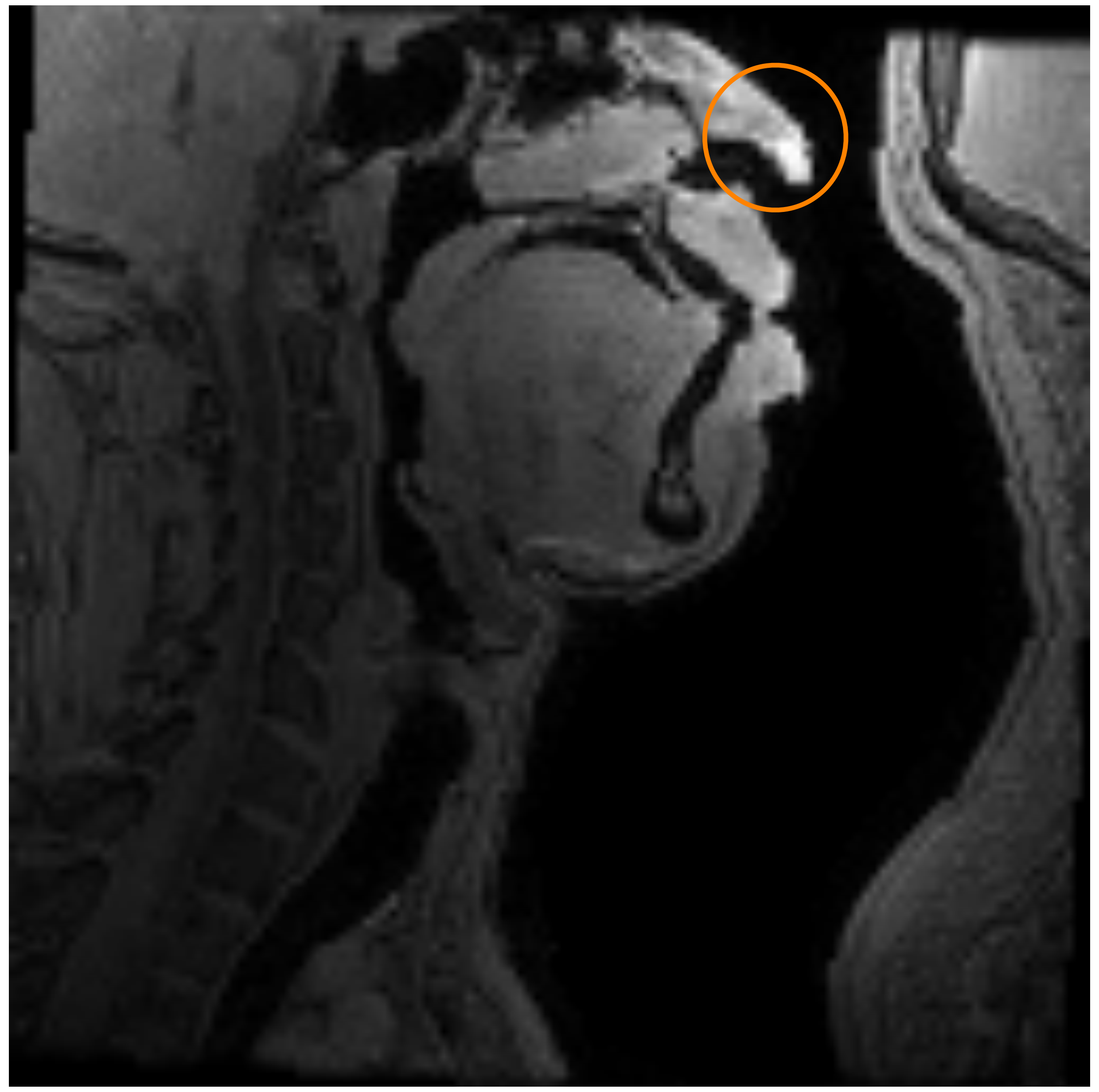


imaging metric

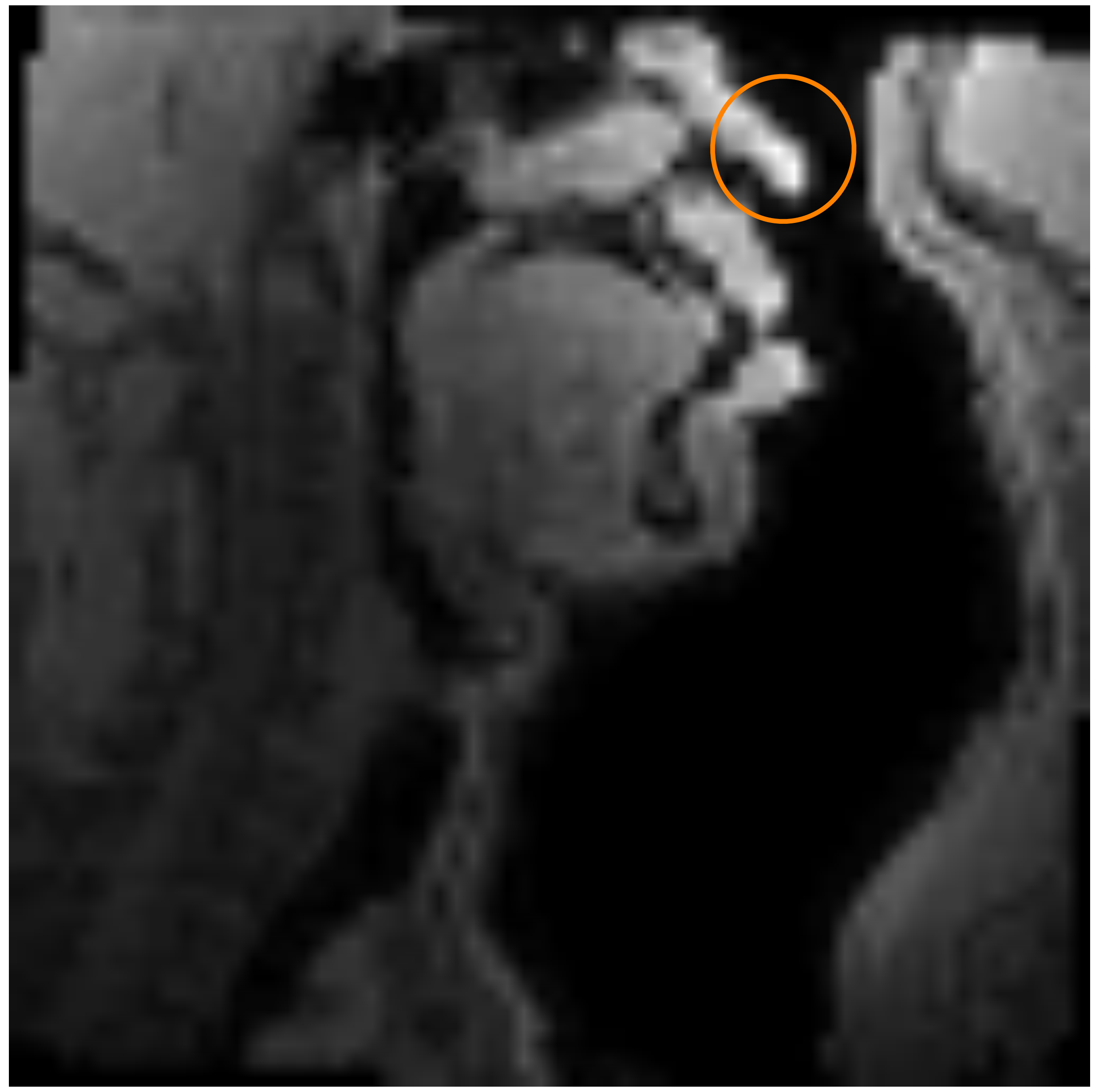
$$\text{PSNR}\,(X, X_r) = 10\log_{10}\frac{\max|X_r|^2}{MSE}$$

$$\text{MSE}\,(X, X_r) = \frac{1}{NM}\sum_{i}^{N}\sum_{i}^{M}|X[i,j] - X_r[i,j]|^2$$

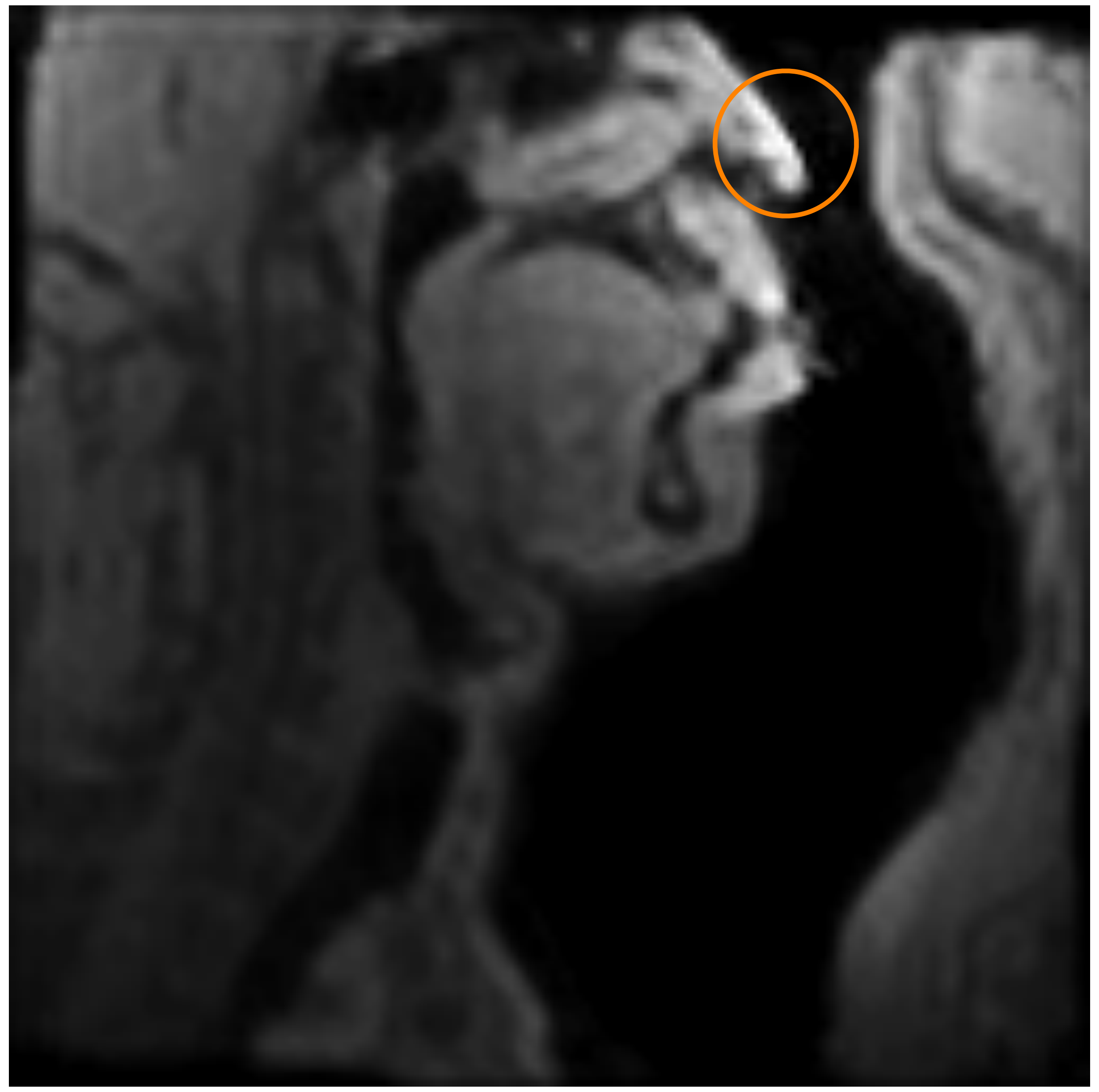
Qualitative Results (phase 1)



High resolution GT



Low resolution input



High resolution output

Qualitative Results (phase 2)

High resolution GT

Low resolution input

High resolution output

Conclusion

Our result improved in phase 2 since

- → We have modified the network from 2-step training to 1 step
- → preprocessing in k-space domain rather than image domain
- → More samples for training

Thank you

IOWA