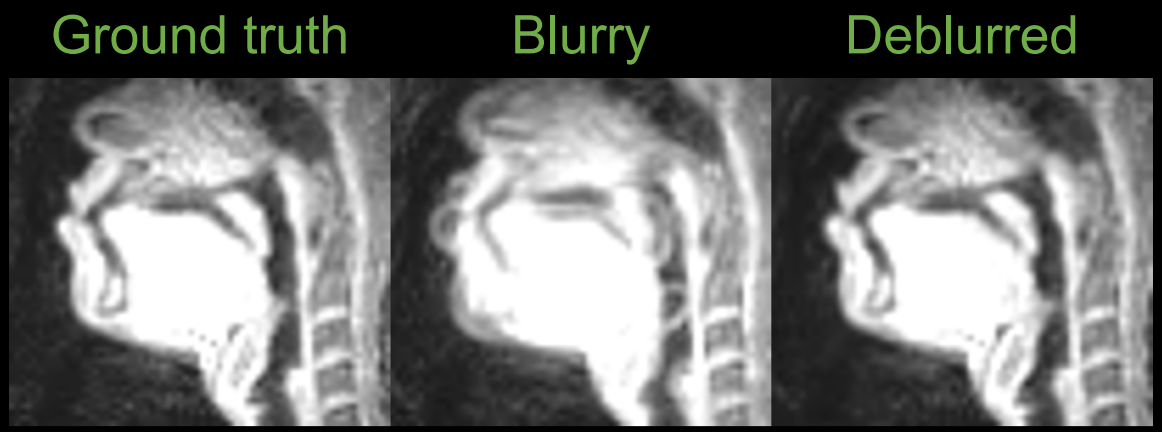


Calibrationless deblurring of spiral RT-MRI of speech production using CNNs

Yongwan Lim, Yannick Bliesener,
Shrikanth Narayanan, Krishna S. Nayak

Ming Hsieh Department of Electrical and Computer Engineering, Viterbi School of Engineering,

University of Southern California, Los Angeles, California, USA

USC Viterbi School of Engineering

Abstract #0673 **Plasma #7**

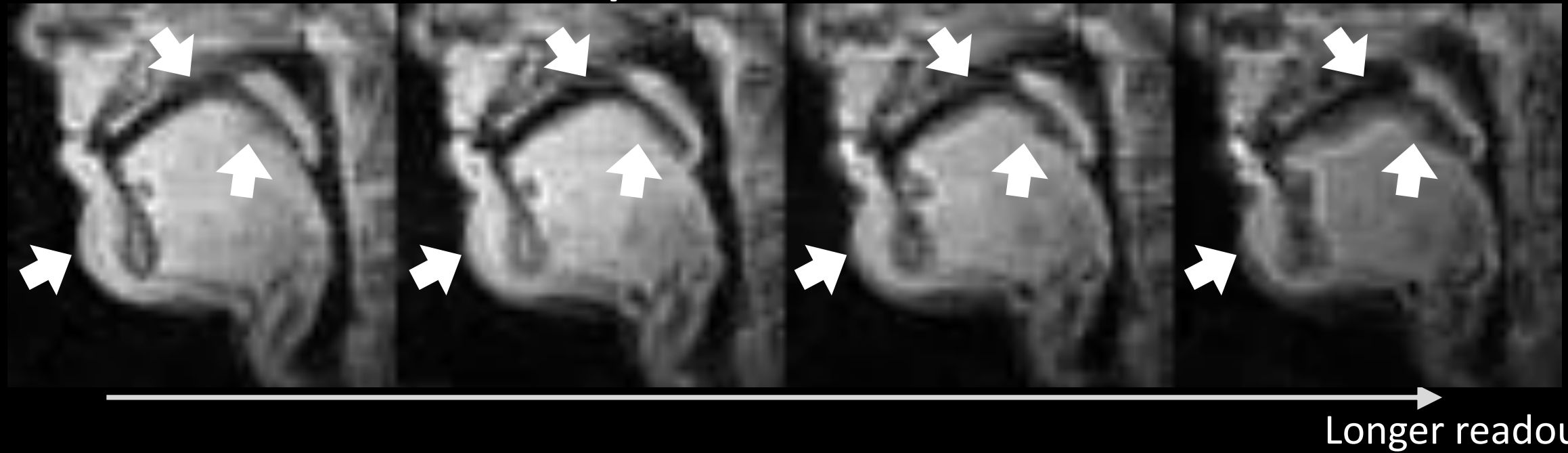
Declaration of Financial Interests or Relationships

Speaker Name: Yongwan Lim

I have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

Space-Time Variant Blur

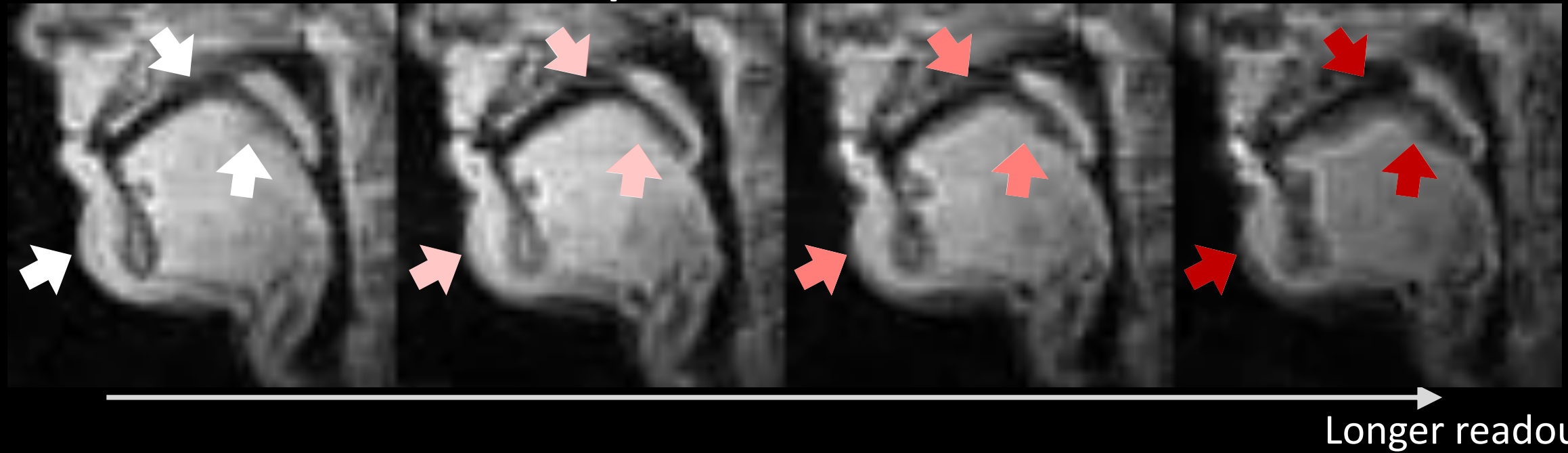
Spiral RT-MRI @1.5T



- Due to 1) off-resonance at tissue boundary and 2) object motion
- Most significantly at *tissue boundary*
- Severe with *longer spiral readout*

Space-Time Variant Blur

Spiral RT-MRI @1.5T

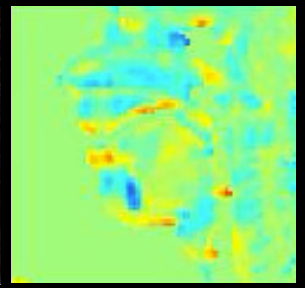


- Due to 1) off-resonance at tissue boundary and 2) object motion
- Most significantly at *tissue boundary*
- Severe with *longer spiral readout*

Off-resonance Deblurring

Blurred Image

Field Map

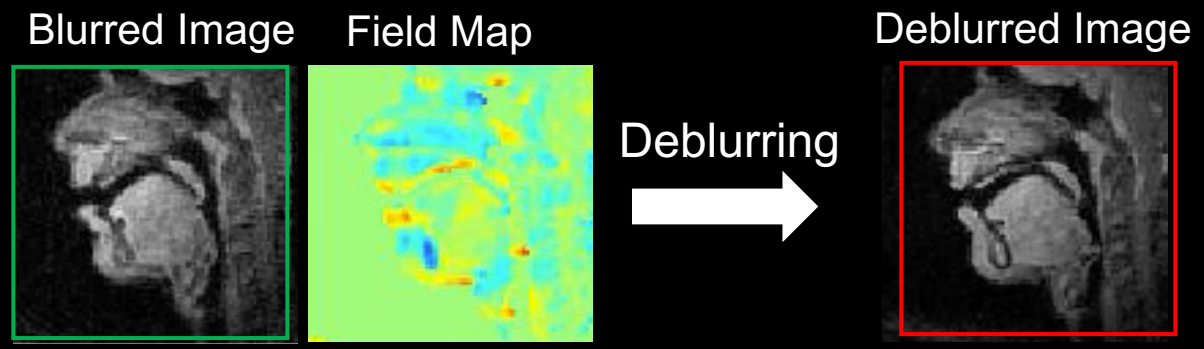


Deblurring

Deblurred Image

1. KS Nayak et al, MRM. 2001
2. BP Sutton et al, JMRI. 2010
3. Y Lim et al. MRM. 2019
4. DC Noll et al, MRM. 1992

Off-resonance Deblurring

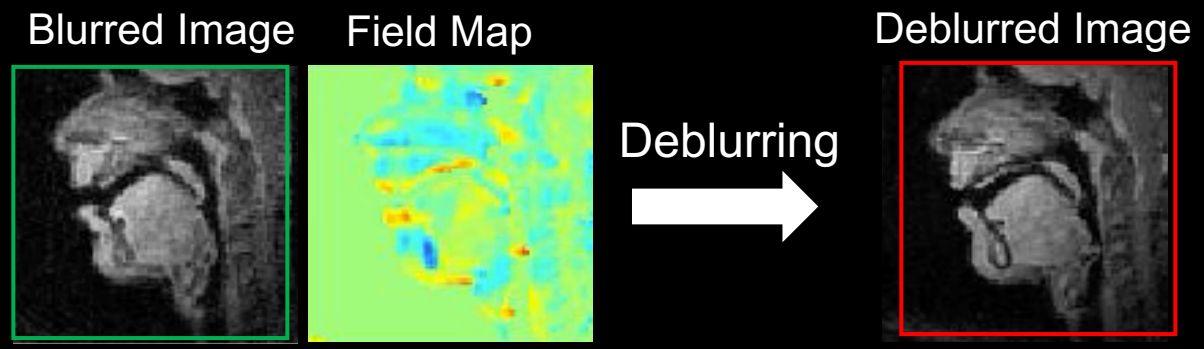


- Standard Approaches:
  - Field map from dual-TE[1,2] (cf. single-TE[3] or auto-focus[4])
    - (X) Often reduces scan efficiency
    - (X) Already-distorted image

- Machine Learning Approaches:
  - Off-ResNet[5]
  - **This Work: DORC-CNN**
    - Dynamic Off-Resonance Correction using CNN

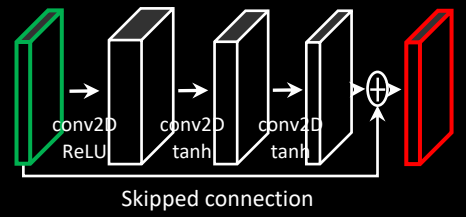
1. KS Nayak et al, MRM. 2001
2. BP Sutton et al, JMRI. 2010
3. Y Lim et al. MRM. 2019
4. DC Noll et al, MRM. 1992
5. D Zeng et al, ISMRM. 2018

Off-resonance Deblurring



- Standard Approaches:
  - Field map from dual-TE[1,2] (cf. single-TE[3] or auto-focus[4])
    - (X) Often reduces scan efficiency
    - (X) Already-distorted image

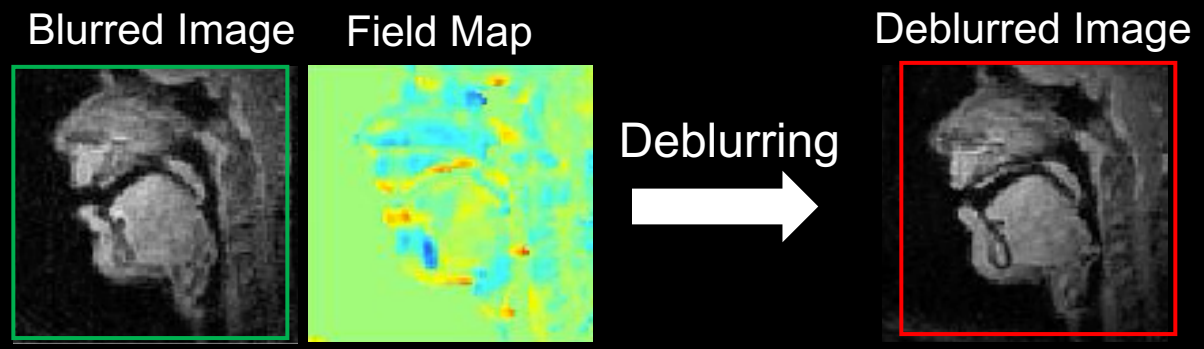
Convolutional Neural Networks



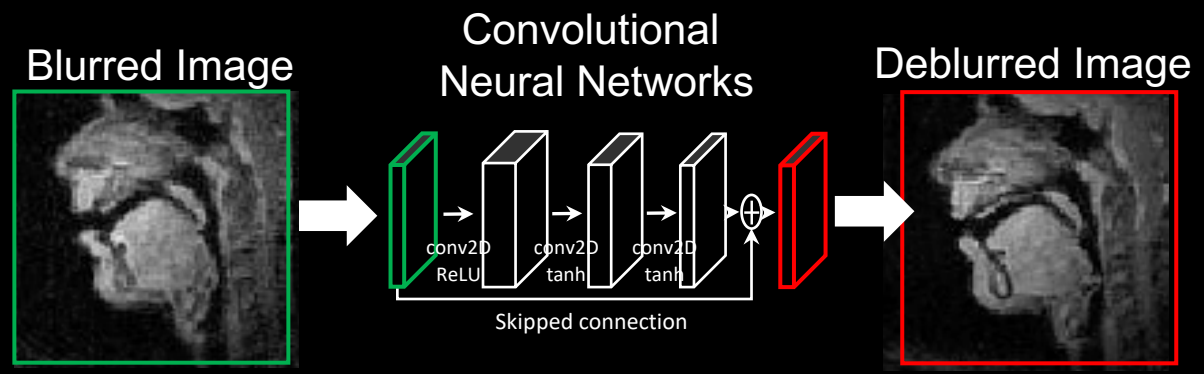
- Machine Learning Approaches:
  - Off-ResNet[5]
  - **This Work: DORC-CNN**
    - Dynamic Off-Resonance Correction using CNN

1. KS Nayak et al, MRM. 2001
2. BP Sutton et al, JMRI. 2010
3. Y Lim et al. MRM. 2019
4. DC Noll et al, MRM. 1992
5. D Zeng et al, ISMRM. 2018

Off-resonance Deblurring



- Standard Approaches:
  - Field map from dual-TE[1,2] (cf. single-TE[3] or auto-focus[4])
    - (X) Often reduces scan efficiency
    - (X) Already-distorted image



- Machine Learning Approaches:
  - Off-ResNet[5]
  - **This Work: DORC-CNN**
    - Dynamic Off-Resonance Correction using CNN

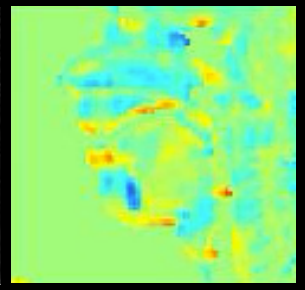
1. KS Nayak et al, MRM. 2001
2. BP Sutton et al, JMRI. 2010
3. Y Lim et al. MRM. 2019
4. DC Noll et al, MRM. 1992
5. D Zeng et al, ISMRM. 2018

USC Viterbi School of Engineering

Proposed Framework: DORC-CNN

Blurred Image

Field Map



Deblurring[1]

Deblurred Image

Deblur residual off-resonance at *short* readout[1]

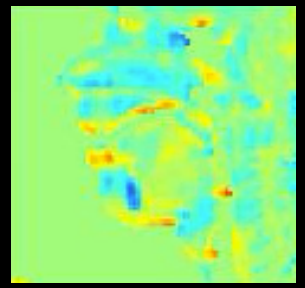
Simulate ***space-variant blur*** at *longer* readout

Train CNNs and Infer

1. Y Lim et al. MRM. 2019

Proposed Framework: DORC-CNN

Field Map



Ground Truth

Deblur residual off-resonance at *short* readout[1]

↓

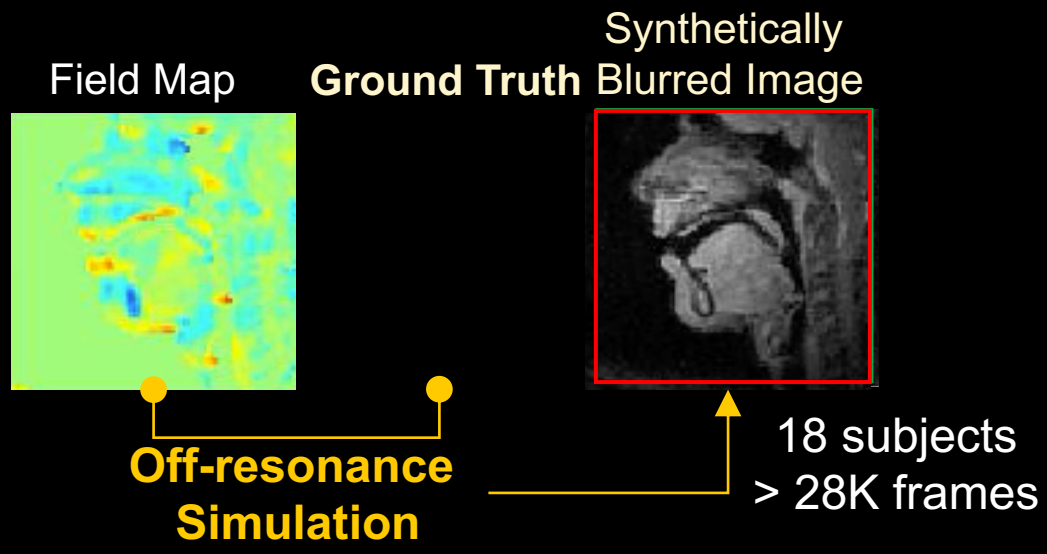
Simulate ***space-variant blur*** at *longer* readout

↓

Train CNNs and Infer

1. Y Lim et al. MRM. 2019

Proposed Framework: DORC-CNN



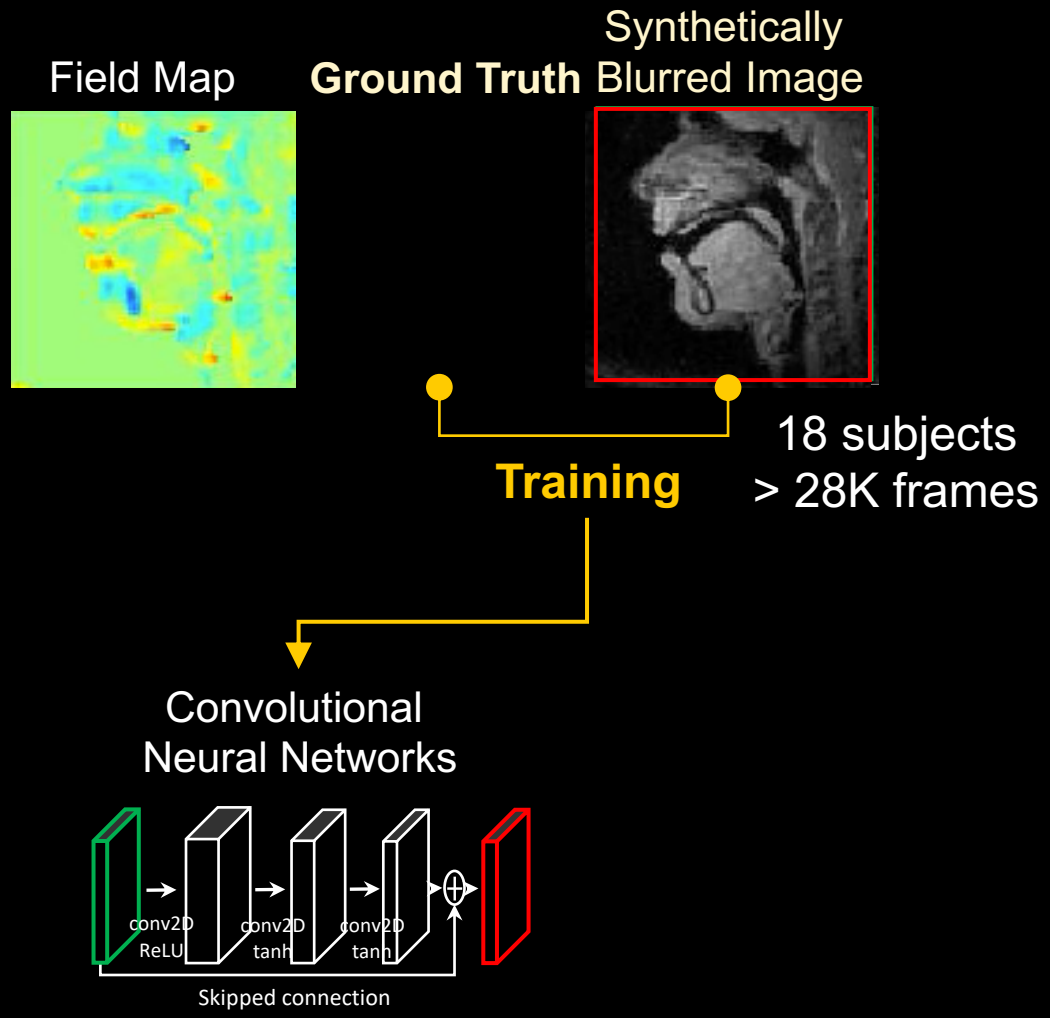
Deblur residual off-resonance at *short* readout[1]

Simulate ***space-variant blur*** at *longer* readout

Train CNNs and Infer

1. Y Lim et al. MRM. 2019

Proposed Framework: DORC-CNN



Deblur residual off-resonance at *short* readout[1]

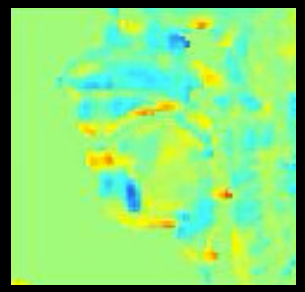
Simulate ***space-variant blur*** at *longer* readout

Train CNNs and Infer

1. Y Lim et al. MRM. 2019

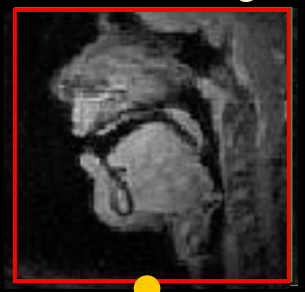
USC Viterbi School of Engineering

Proposed Framework: DORC-CNN



Field Map

Ground Truth



Synthetically Blurred Image

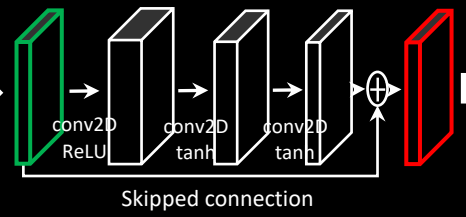
Training

18 subjects
> 28K frames

Inference

Blurred Image

Convolutional Neural Networks



Deblurred Image

Deblur residual off-resonance at *short* readout[1]

Simulate ***space-variant blur*** at *longer* readout

Train CNNs and Infer

1. Y Lim et al. MRM. 2019

USC Viterbi School of Engineering

Result: Short Readout Real Data

Uncorrected | Previous Method[1] | Proposed

Readout = 2.52 ms

Temporal resolution = 78 ms

USC Viterbi School of Engineering

1. Y Lim et al. MRM. 2019

Result: Short Readout Real Data

Uncorrected | Previous Method[1] | Proposed

Readout = 2.52 ms

Temporal resolution = 78 ms

USC Viterbi School of Engineering

1. Y Lim et al. MRM. 2019

Result: Long Readout Real Data

Uncorrected | Previous Method[1] | Proposed

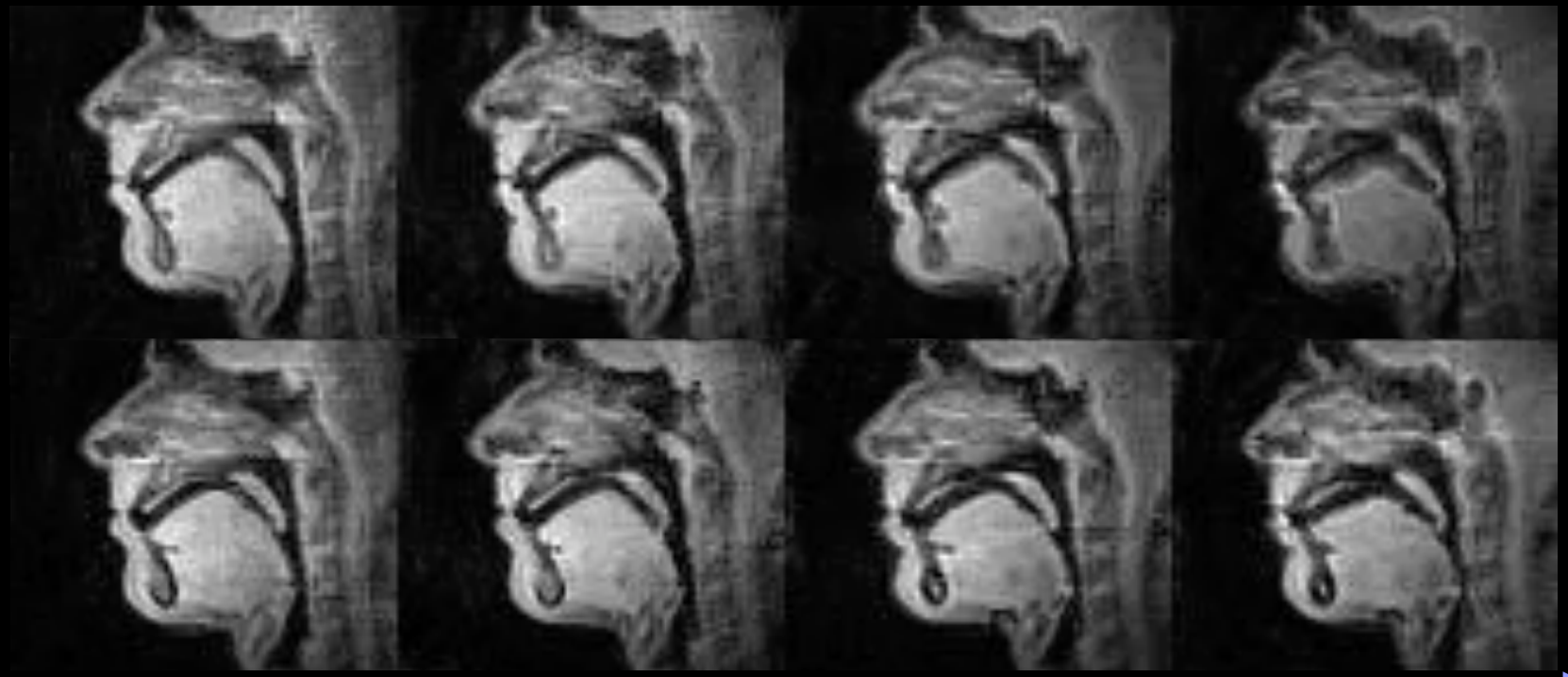
Readout = 7.94 ms

Temporal resolution = 46 ms

1. Y Lim et al. MRM. 2019

Calibrationless deblurring of spiral RT-MRI of speech production using CNNs

PLASMA 7



Uncorrected

DORC-CNN

Longer readout

USC Viterbi School of Engineering

Question? yongwanl@usc.edu