Oct, 2017

Deep reconstruction of security data & AAPM Grand Challenge

Quanzheng Li

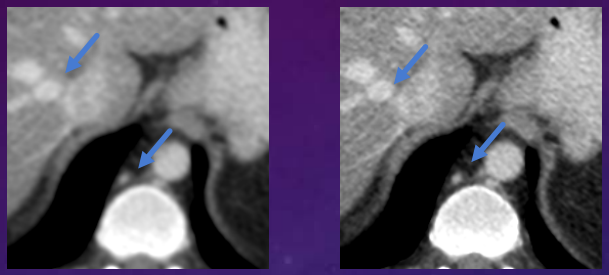
Core Faculty, Center for Clinical Data Science, Harvard Medical School
Director, Computational Imaging and Artificial Intelligence lab, Gordon Center, Mass General Hospital

HARVARD MEDICAL SCHOOL

MASSACHUSETTS GENERAL HOSPITAL

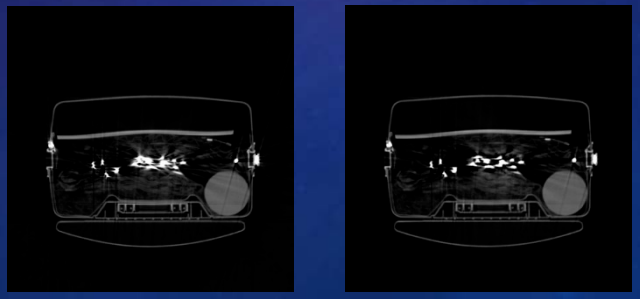
Summary

- An iterative algorithm with Spatially Encoded Non-Local Penalty is developed, and won AAPM Low Dose CT Grant Challenge



- An iterative recon with deep learning based prior is developed and published on TMI special issue on low dose CT

- Similar iterative recon with deep learning based prior is applied to security CT



Wu D, et al. Iterative Low-dose CT Reconstruction with Priors Trained by Artificial Neural Network. Transactions on Medical Imaging (accepted).

Low Dose CT Grand Challenge

- First CT Grand Challenge
- Public Available Data and Parameters
- An Open Test Bed for CT Algorithms

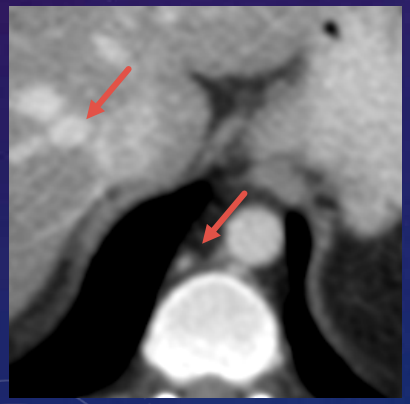
Low Dose CT Grand Challenge

NIH National Institute of Biomedical Imaging and Bioengineering
AAPM American Association of Physicists in Medicine
MAYO CLINIC
CT Clinical Innovation Center

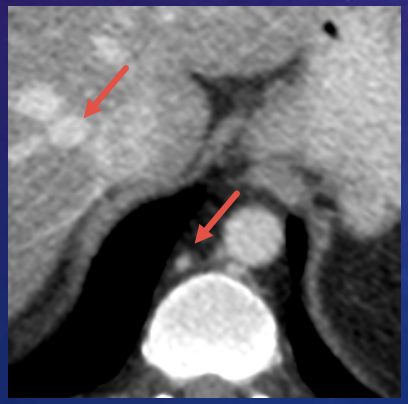
First Place!

- World Wide Participants

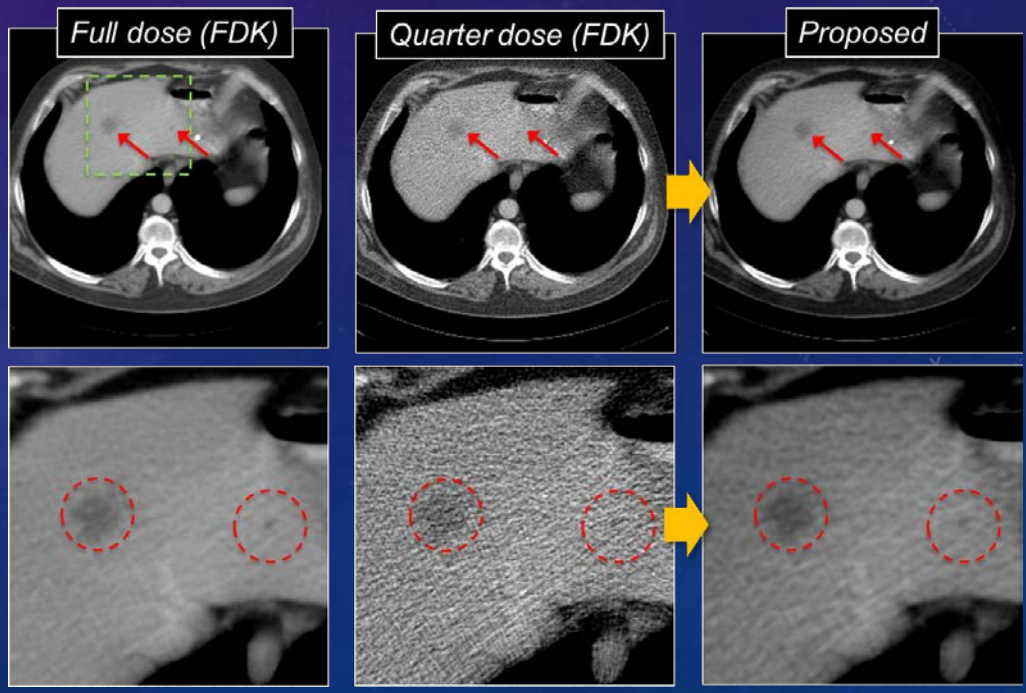
Spatially Encoded Non-Local Penalty



Traditional non-local mean

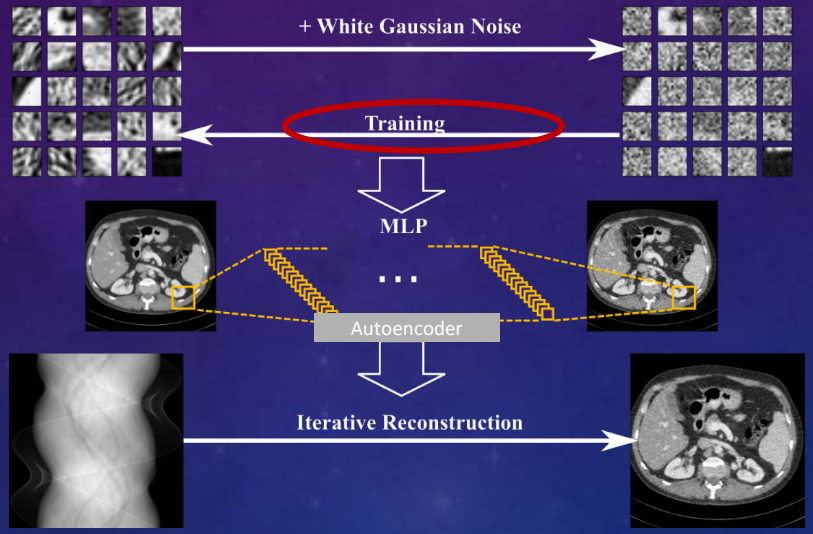


New non-local mean



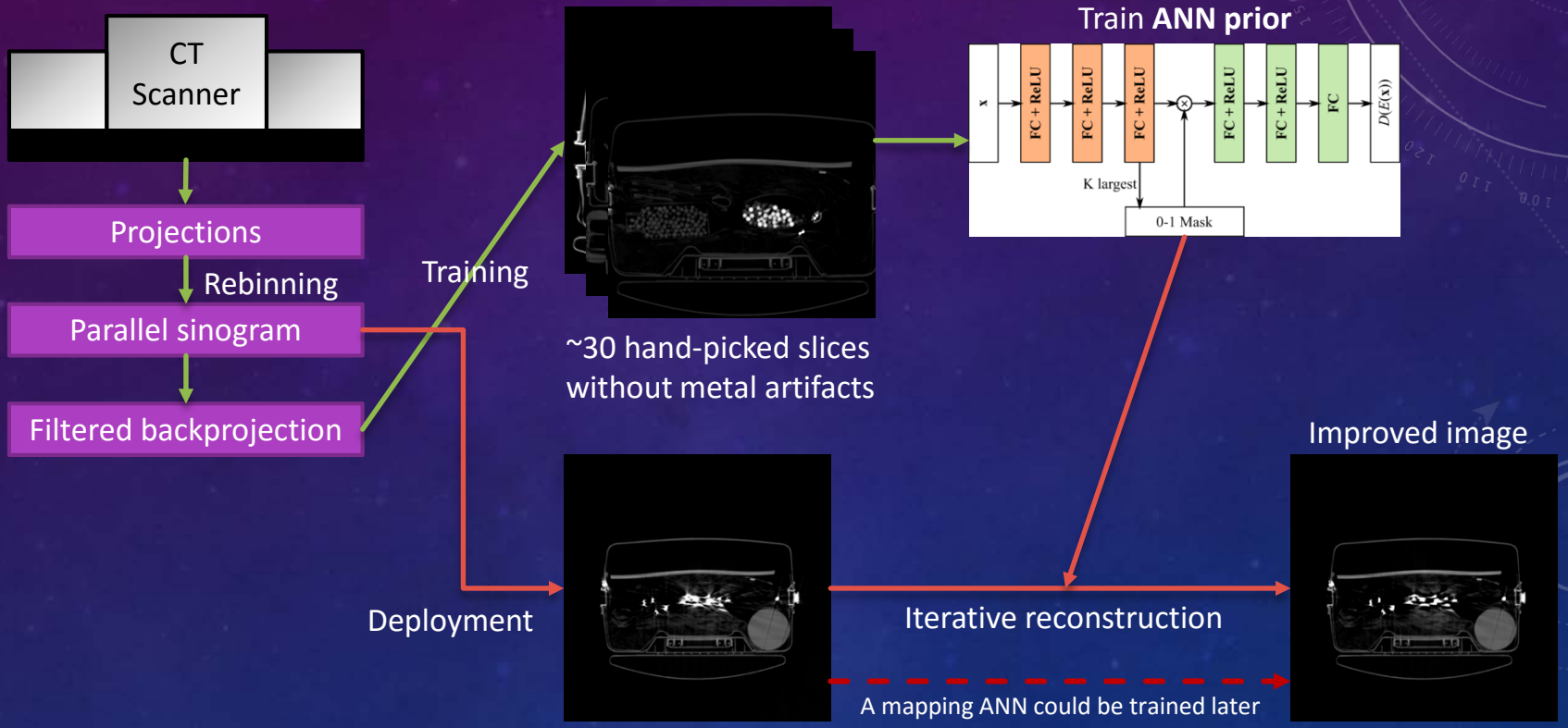
DL based Recon: Clinical Data

- Because noises in **x** changes during the iterations, it has to be learned in an **unsupervised** way;
- A solution with denoising autoencoders:



Wu D, et al. Iterative Low-dose CT Reconstruction with Priors Trained by Artificial Neural Network. Transactions on Medical Imaging (accepted).

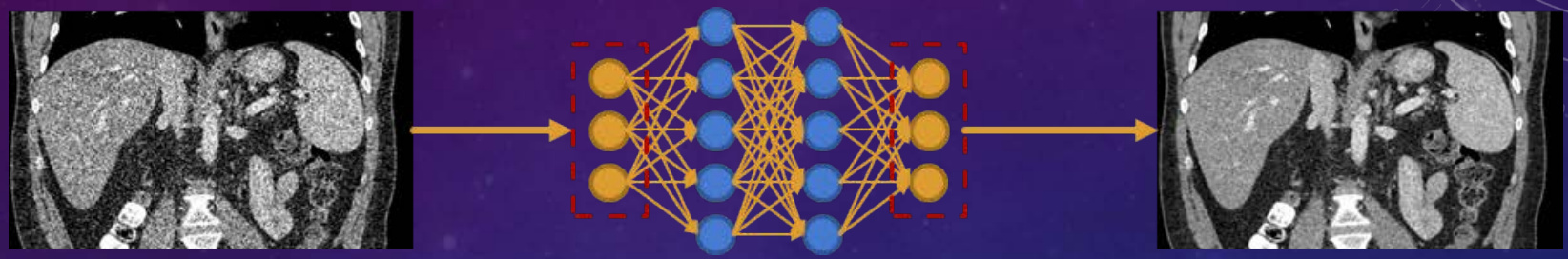
DL BASE RECON: TSA DATA



ML Knowledge can be transferred to security, and significantly improve image quality.

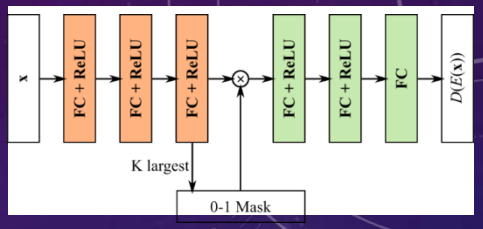
MACHINE LEARNING BASED RECONSTRUCTION

- Artificial neural networks (ANN) have great nonlinear mapping ability

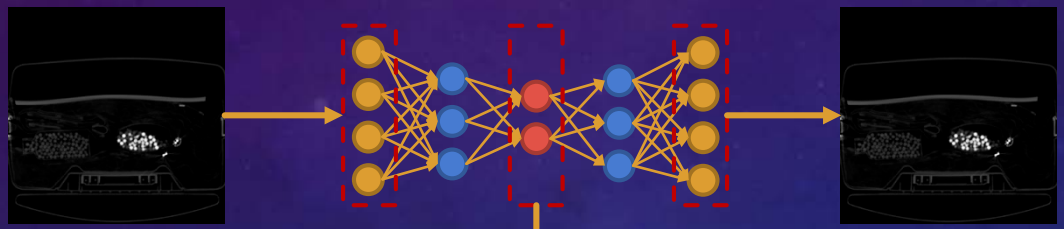


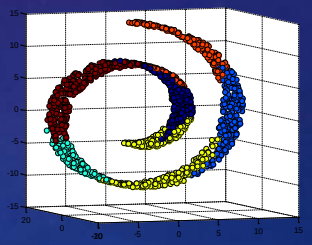
- Problem
  - Require “ground truth” data: unavailable for security CT
- Solution: unsupervised learning
  - Train ANN on clean data
  - Apply ANN to “dirty” data during reconstruction
  - Train another “mapping” ANN for real-time application

ANN PRIOR: AUTOENCODER



- An ANN that maps clean images back to themselves





*The ANN was trained on patches in practice

The features mapped to images to some “computer understandable” manifold:
It told the computer where clean data was.

ITERATIVE RECONSTRUCTION

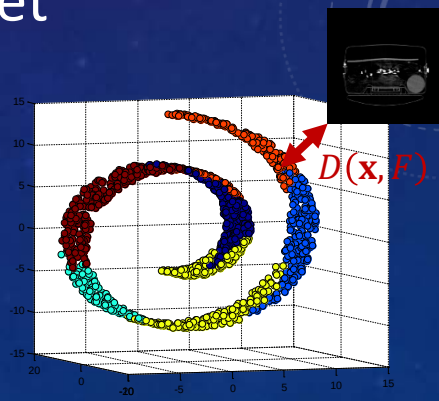
- Penalized reconstruction

$$\mathbf{x} = \arg\min \|\mathbf{Ax} - \mathbf{b}\|_{\mathbf{w}} + \beta D(\mathbf{x}, F)$$

Noise weighted data loss

Distance between x and trained space

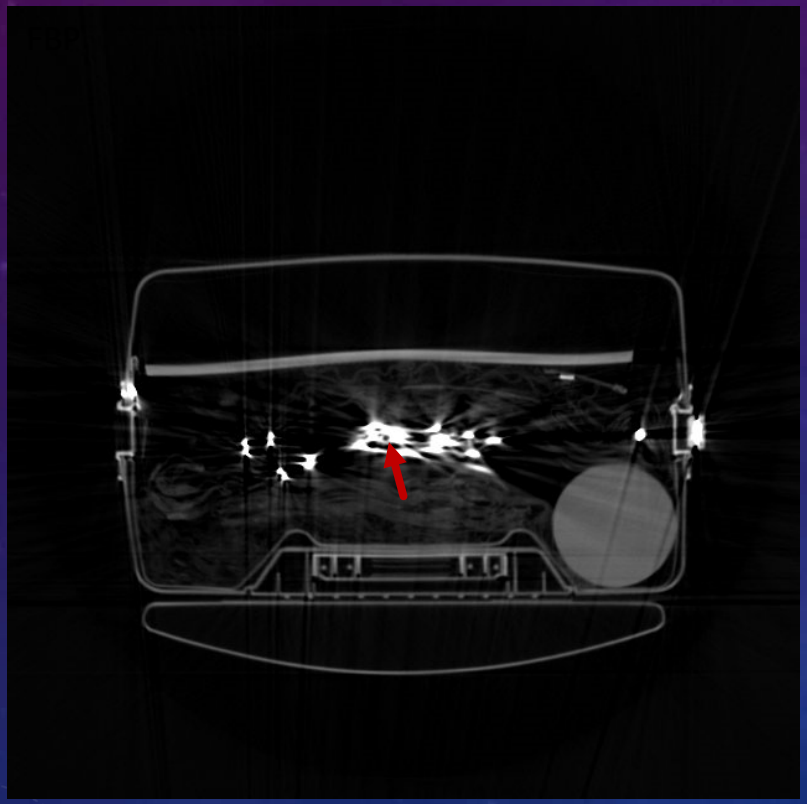
- No explicit metal artifacts reduction applied yet

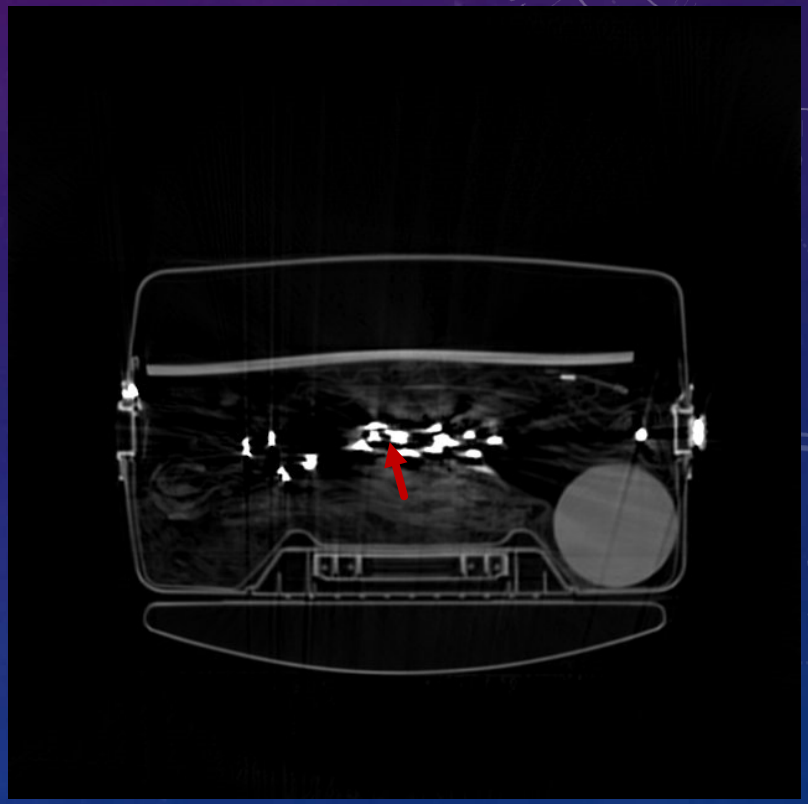


PRELIMINARY RESULTS

- Data
  - Provided by Boston University
  - Imatron C300 electronic beam tomography (EBT) medical CT scanner
  - Reconstructed at MGH

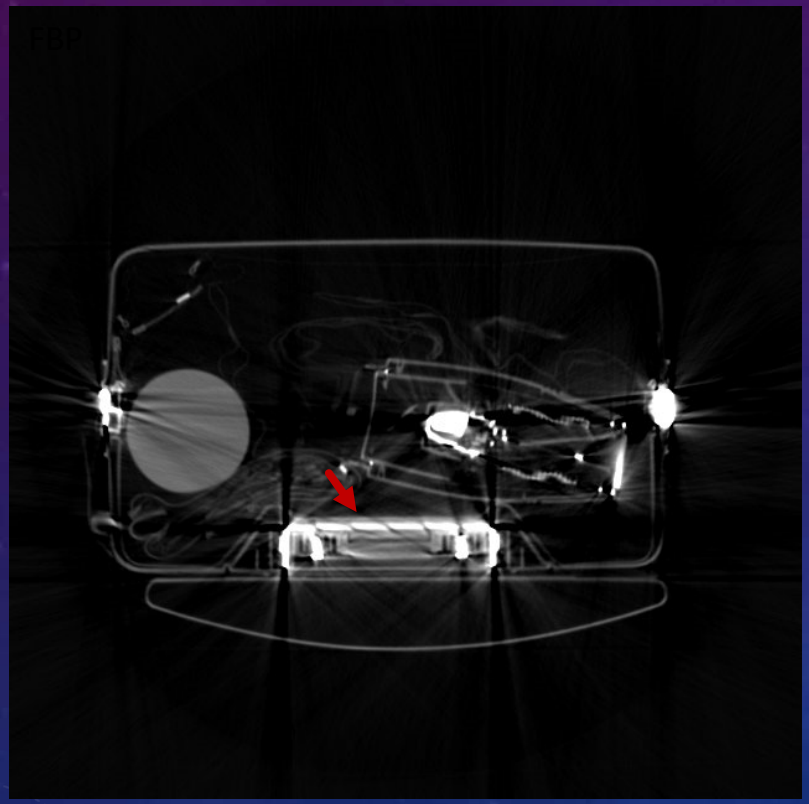
PRELIMINARY RESULTS

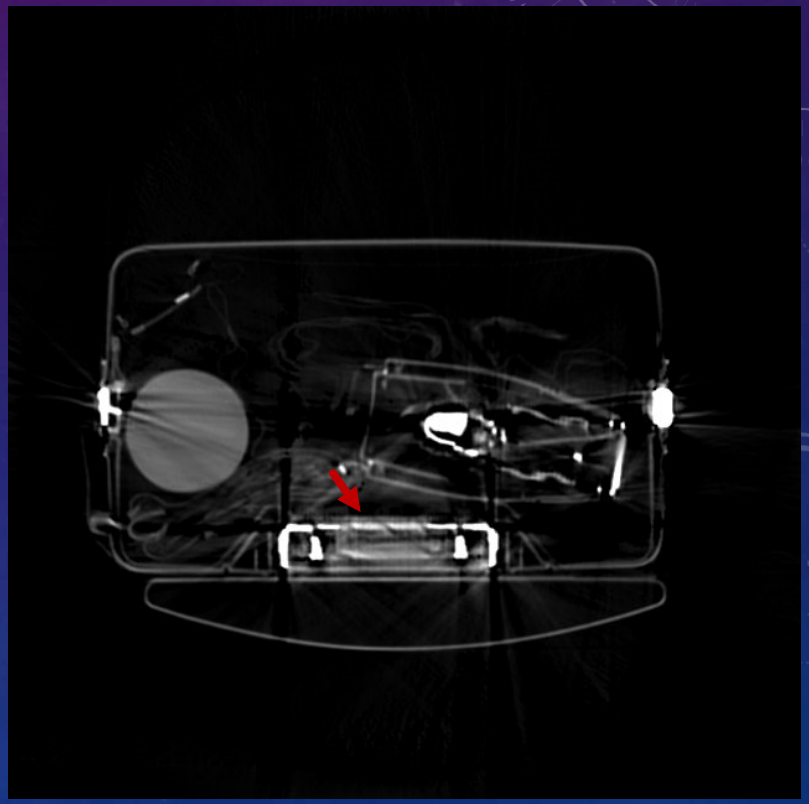




PRELIMINARY RESULTS

PRELIMINARY RESULTS





CONCLUSION AND FUTURE WORKS

- With unsupervised ANN approach
  - We are able to commence training without ground truth
  - Promising artifacts reduction potential was shown
- Future improvements
  - Incorporate explicit metal artifacts reduction technique
  - Train the final “mapping” ANN for real-time application

CIAI Lab

Image Recon and Analysis

Image Recon:

- PET
- CT
  - Low Dose CT
  - Spectrum CT/Material Decomposition
  - Phase Contrast CT
  - Static CT / Nano CT
- MRI/Optical
- Microscope – EM
- Hybrid: PET/CT, PET/MRI

Image Analysis:

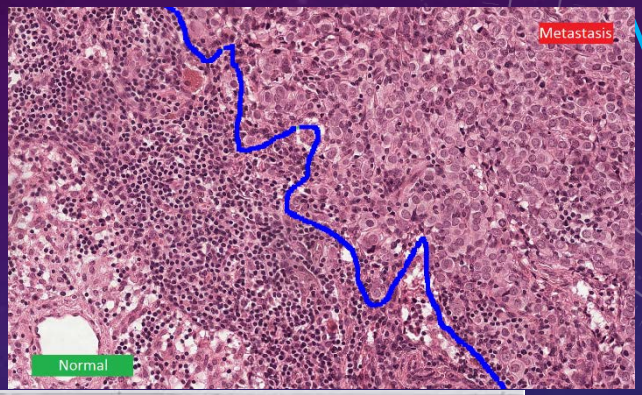
- Image Denoising and Restoration
- Segmentation and Registration
- Novel Image Biomarkers
- Radiomics/Radiogenomics
- Diagnosis/Progonosis

Low Dose CT Grand Challenge

NIH National Institute of Biomedical Imaging and Bioengineering
AAPM American Association of Physicists in Medicine
Mayo Clinic
CT Clinical Innovation Center

First Place!

Medicine



n Networks

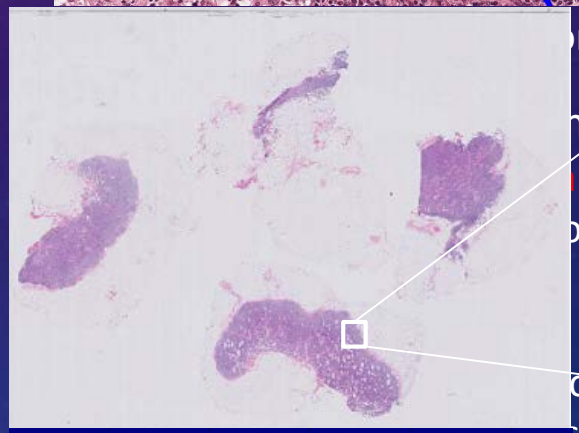
ns:

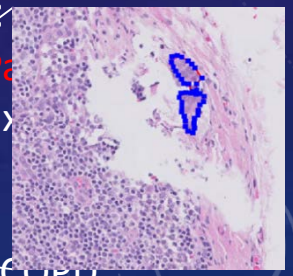
l Pa

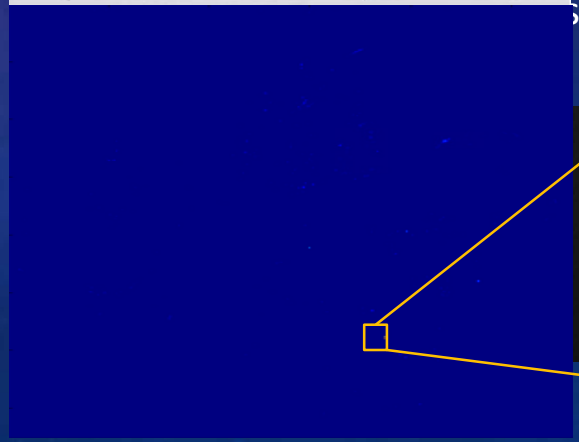
orax

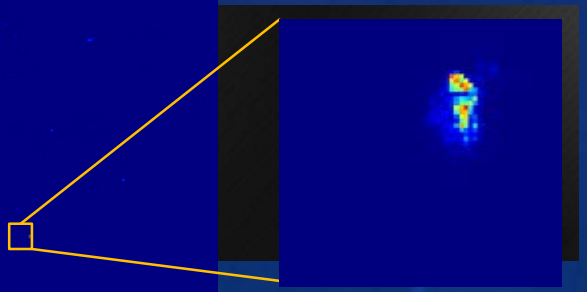
of COPD

sion of Diabete









Thanks for your attention !

Li.Quanzheng@mgh.harvard.edu