Extreme Sparse View X-Ray CT for Carry-on Bag Screening

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So What? Who Cares?

- **Space:** Weapons concealed in the carry-on baggage.
  - Need 3D recon
  - Moving gantry is problematic → stationary CT
- **Problem:** Extreme sparse view CT: low quality reconstruction
- **Solution:** Un(semi)supervised deep learning CT reconstruction
- **Results:** accurate 3D recon < 5sec
- **TRL:** 8
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Introduction

Prof. Jong Chul Ye

- Endowed Chair Professor at KAIST
- Vice president of Korean Society for Artificial Intelligence in Medicine (KoSAIM)
- General Co-Chair, IEEE Sym. Biomedical Imaging (ISBI), 2020, Iowa City, USA
- Associated Editor, Senior Editor for
  - IEEE Signal Processing Magazine
  - Magnetic Resonance in Medicine (MRI)
  - Physics in Medicine and Biology (x-ray CT)
  - BMC Biomedical Engineering (Imaging section)

- A pioneer in machine learning for image reconstruction
  - World first AI recon for AAPM Low Dose CT Grand Challenge, 2016
  - One of the world first AI reconstructions for CT, MRI, US, PET, Optics, electron microscopy, etc.

- 98 Journal Papers in top medical imaging journals
  - Including invited review papers for machine learning for medical image reconstruction (The Proceedings of IEEE, IEEE Signal Processing Magazine)

- Keynote speaker in AI-driven radiological imaging
  - ISMRM Annual Meetings, Montreal, CA, 2019
  - ICCV. LCI Workshop, Seoul, Korea, 2019
  - Applied Inverse Problems (AIP), France, 2019
  - MICCAI PRIME Workshop, Shenzhen, 2019
  - IMA Workshop for Computational Imaging, MN, USA, 2019
  - Tutorial for ISBI, Venice, 2019
  - SPIE Medical Imaging, Houston, USA, 2018
  - X-ray CT Meeting, Salt Lake City, USA, 2018
  - IEEE EMBS International Summer School on Biomedical Imaging, MICCAI Workshop, Brittany, France, 2018
  - MICCAI MLMIR Workshop, Granada, Spain 2018
Carry-on Bag CT Scanner

- Major airports are very busy
- 2-D carry-on bag scan
  - Cons: many false alarms $\rightarrow$ scan throughput decrease
- 3-D CT scan of carry-on bags
  - Pro: reduces the ambiguities $\rightarrow$ increase the scan throughput
  - Cons: a gantry does not last long
  - Solution: Needs stationary CT
Prototype 9 View Stationary CT

- Hardware developed by GEMSS, Inc. Korea.
- 9 mono blocks with 160kV, 1mA
- Fan angle determined by considering the checked baggage size
- Sequential x-ray illumination
Acquisition Concept

Sequence control of multi-source and detectors
View Generation Network

Neural Network Training

- Our neural Network was trained with bottles, parts, etc.
- Once it was trained, the trained neural network could be used for unseen carry-on bags
Deep Learning
Han et al, CT meetings, 2018
Proposed Recon time < 5 sec

FBP
MBIR (TV)
IMAGE-CNN

Proposed
Proposed (simple ver.)

Recon time < 5 sec
Summary

- Extreme sparse view CT recon using deep learning
- Successful demonstration of 9 view carry-on bag CT
  - Hardware IP
    - GEMSS Medical Co → Start up: SSTLab Inc.
    - 1 prototype system
    - No TSA evaluation yet
  - Software IP
    - JCY and student: 50%
    - KAIST: 50%