PET image reconstruction with CNN deep learning

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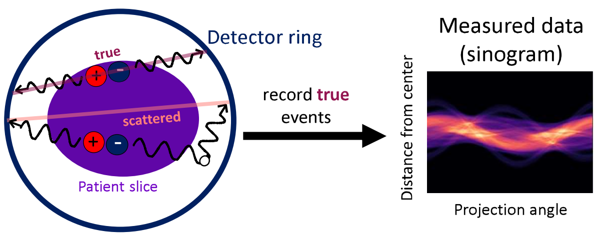
Introduction

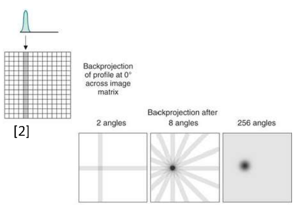
Positron Emission Tomography (PET)

Positron Emission Tomography is a medical imaging modality capable of measuring functionality within the human body. Positrons are introduced to a patient through an activity uptake resulting in photon pairs 180 ° apart.[1] Energy discrimination is used to minimize Compton scattered events.

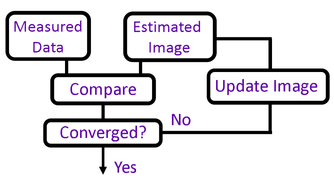


In PET, one of the main challenges is determining how to best reconstruct the images from the sinogram data. The current clinical reconstruction methods include:

#1: Filtered back-projection (FBP)



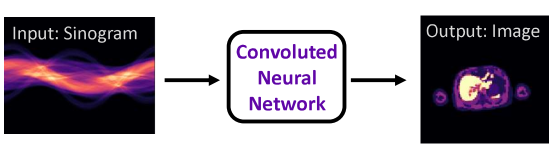
#2: Iterative reconstruction



However, FBP reconstructions introduce blurring effects and iterative reconstructions are computationally expensive.

Convoluted Neural Network (CNN)

A CNN is a type of machine learning network comprised of convolutional layers. It may be trained to generate a specific output when given the corresponding input.



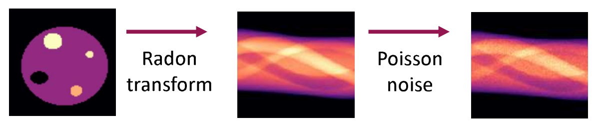
Utilizing a CNN for image reconstruction may decrease computational time, improve image quality and maximize useful information through the use of scattered photons.

Methods

Training/Testing Simulations:

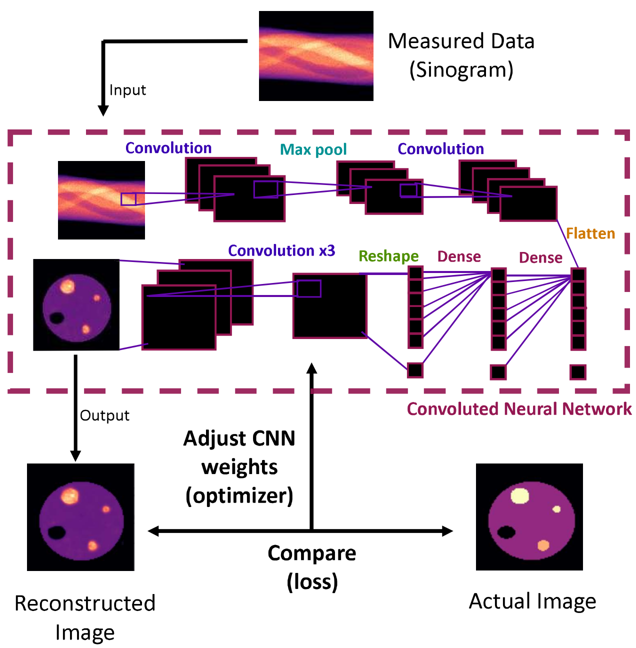
#1: Activity uptake simulation: analytically generated

#2: Sinogram simulation:



Training CNN

100 000 training sets



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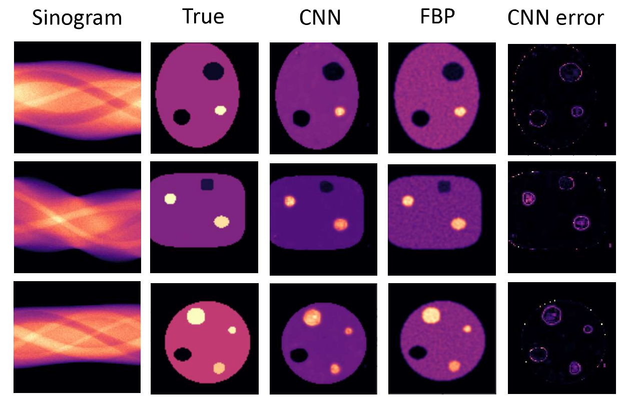
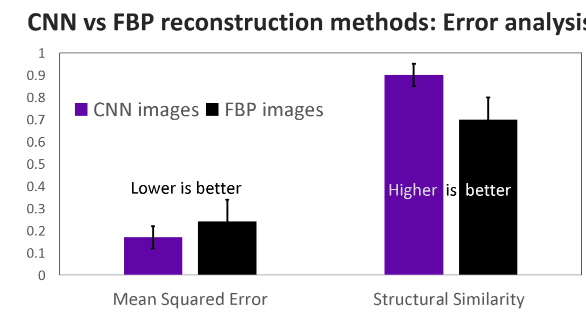
Results

Testing CNN

Poisson loss, adam optimizer, 100 epochs



Error Analysis



Conclusion and Future Work

CNN reconstruction showed lower error and higher similarity than FBP methods. Overall, CNN reconstruction may be used to improve image quality, reduce computational time and expand the amount of useful data measured for PET imaging.

Future Work:

- Realistic sinograms - Monte Carlo simulations
- Energy windows – utilizing Compton scattered events
- Real PET data

References:

[1] T. Foster and M Elbanan. *Electron–positron annihilation.* Radiopaedia. https://radiopaedia.org/articles/electron-positron-annihilation

[2] *Tomographic Reconstruction in Nuclear Medicine.* Feb 2016. Radiology Key. https://radiologykey.com/tomographic-reconstruction-in-nuclear-medicine