Limited-angle DECT Using Mutual Learning and Cross-estimation

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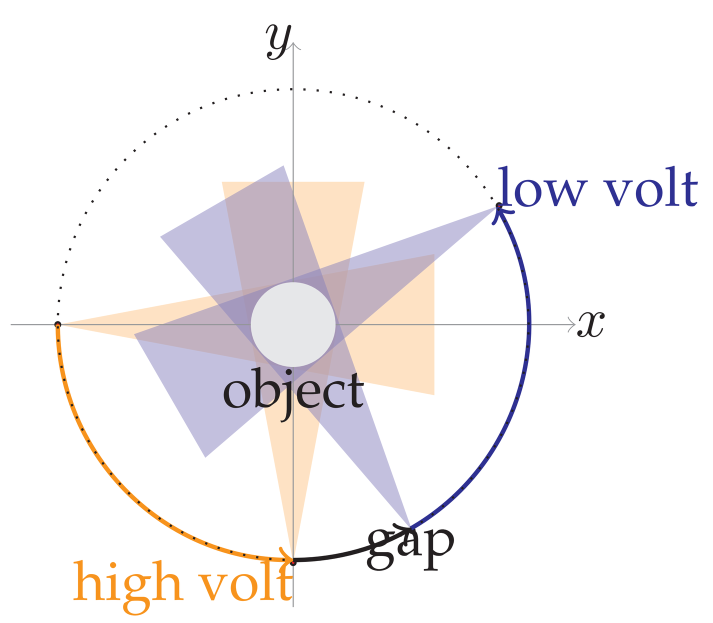
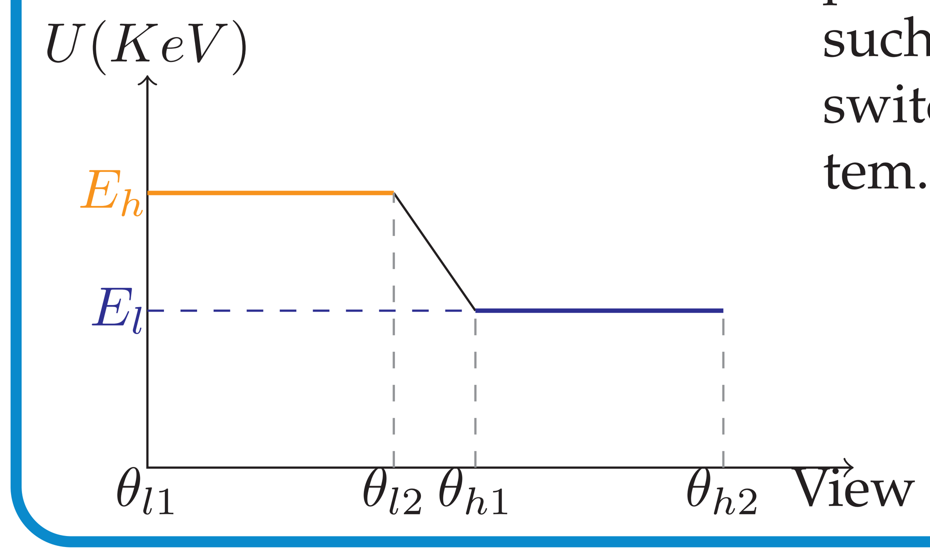
Introduction

- Compared with conventional single energy CT, dual-energy CT (DECT) can differentiate materials.
- For indenpendent reconstruction in DECT, the data of projection is doubled, but it is hopeful to reduce the data required due to the coherence between the projection data at the high and low energies.
- We propose a neural network based method to extract the relationship of linear attenuation coefficients between two X-ray energies, and use this relationship to augment the projection data for reconstrcution.
- Through numerical validation, our method can reduce the angular coverage to 90° for each energy without severe limited-angle artifacts.

Two-arc DECT scan



- Partial of the data from these two arcs forms a number of conjugate sampling pairs
- A voltage transition gap between the two arcs eases the implementation of such a slow-kVp-switching system.



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Mutual Learning and Cross Estimation

- Low-quality images at two energy channels are constructed from all the projection data within the conjugate sampling pairs.
- These two images share identical structural information, with different linear attenuation coefficients. They are used to learn a relationship between linear attenuation coeffcients at two X-ray energies.

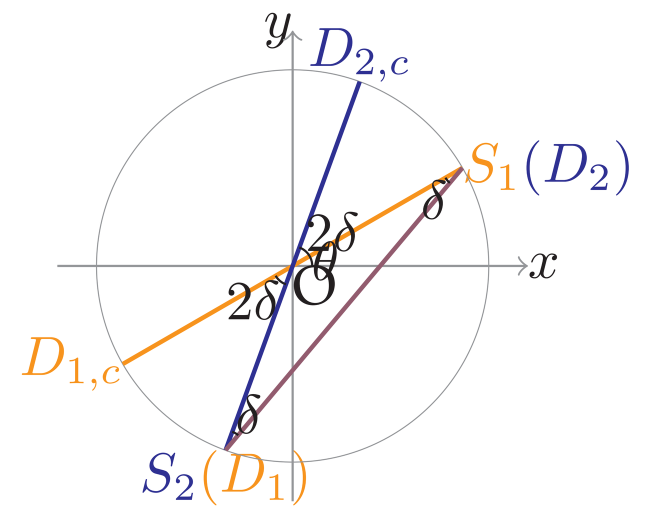
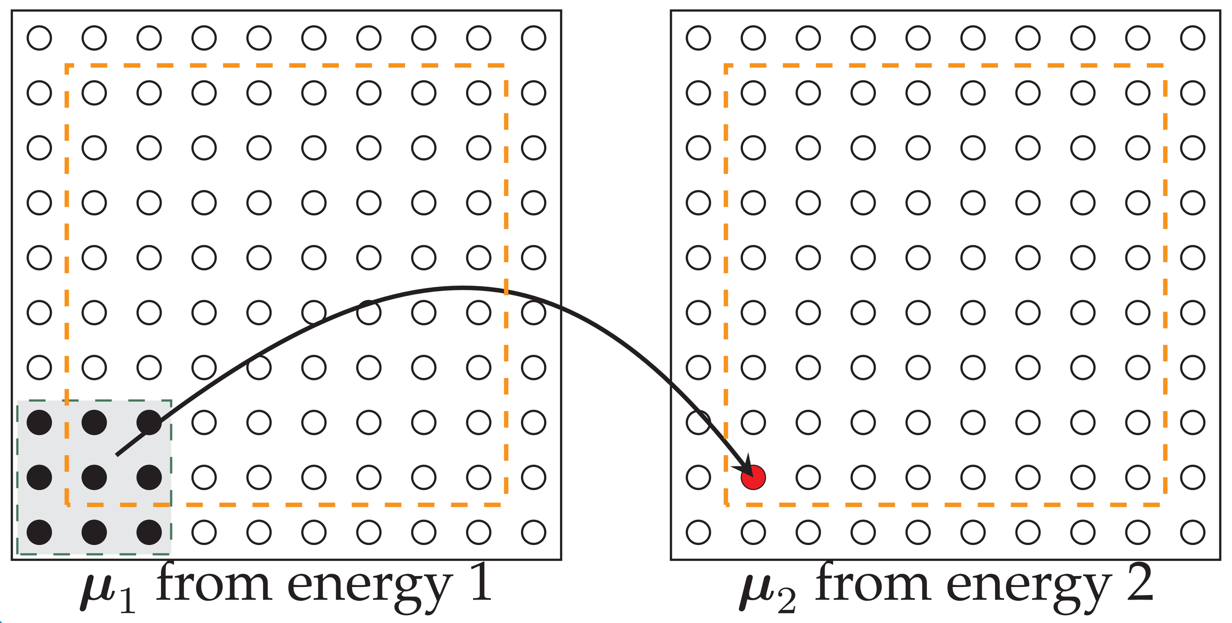


Figure 1: Conjugate sampling pair

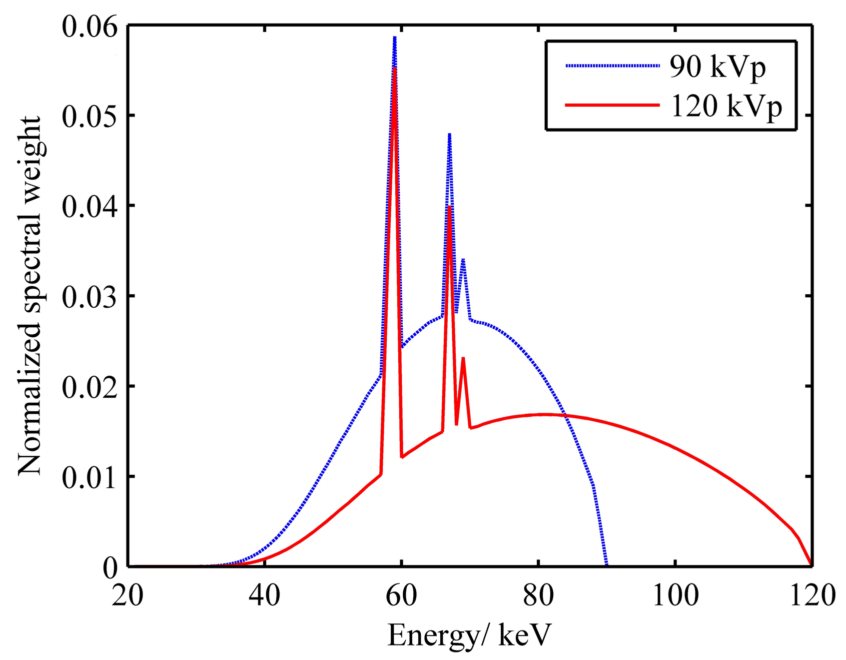


- build a mapping between the projections at different energies $\varphi_{E_1,E_2} : \boldsymbol{p}_{E_1} \rightarrow \boldsymbol{p}_{E_2}$
- Indirectly get the relationship in image domain $\psi_{E_1,E_2} : \boldsymbol{\mu}_{E_1} \rightarrow \boldsymbol{\mu}_{E_2}$

$$\boldsymbol{p}_{E_2} = \varphi_{E_1,E_2}(\boldsymbol{p}_{E_1}) = \mathcal{R}(\varphi_{E_1,E_2}(\mathcal{R}^{-1}(\boldsymbol{p}_{E_1})))$$

- Use a window as the input of the neural network to increase robustness.

Numerical Experiments



Experimental setups:

- Fan beam scan
- $V_h = \{1°, 2°, \ldots, 90°\}$
  $V_l = \{120°, 121°, \ldots, 210°\}$.
- Number of detectors: 960
- Image size: 512 x 512
- Learning and estimation method: Neural networks
- Reconstruction method: OS-SART + TV

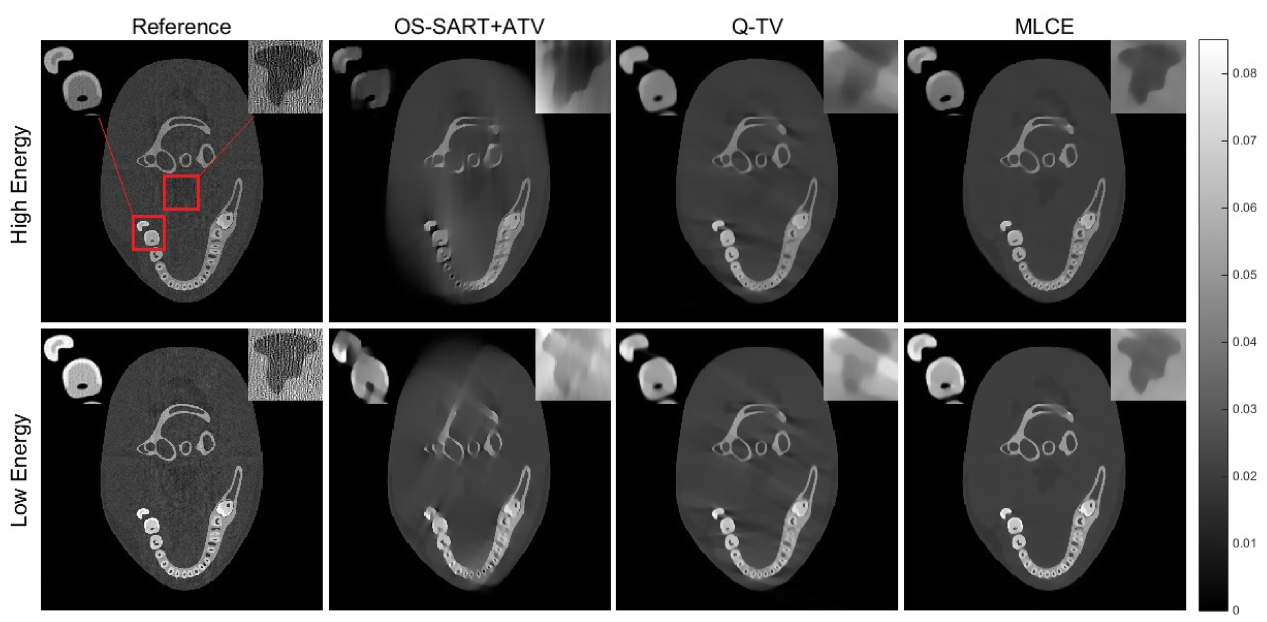


Figure 2: Reconstruction from DECT scans

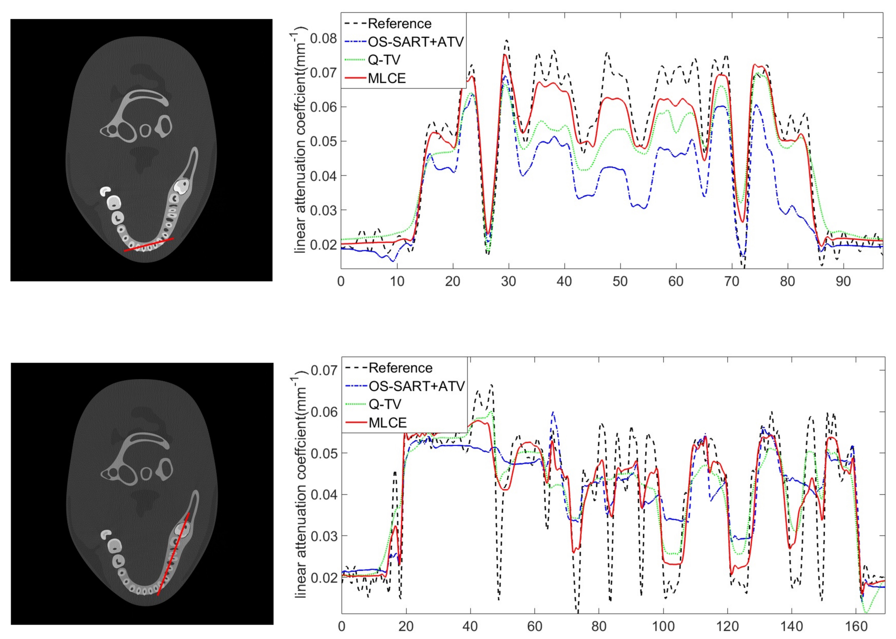
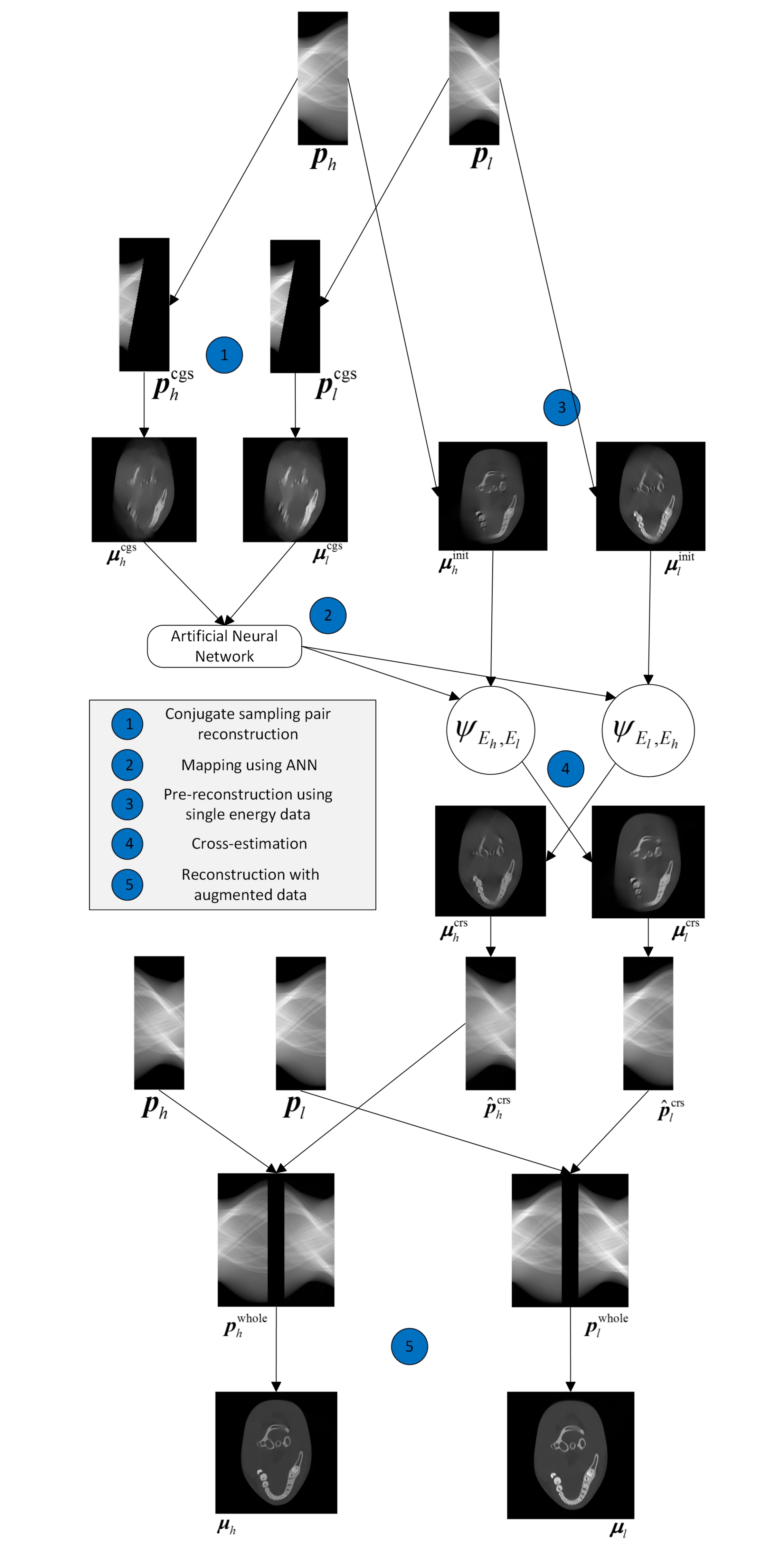


Figure 3: Profiles along the red line

Reconstruction Flowchart



Conclusion

This paper presents a new scanning strategy and a mutual learning approach based on neural networks for DECT to reduce the data requirement and ease DECT implementation. Compared to a common DECT, about 50% of data, which could also mean dose reduction, are saved based on our new MLCE reconstruction method.