3D CBCT CHALLENGE 2024: IMPROVED CONE BEAM CT RECONSTRUCTION USING SWINIR-BASED SINOGRAM AND IMAGE ENHANCEMENT

Sasidhar Alavala, Subrahmanyam Gorthi

Department of Electrical Engineering, IIT Tirupati, India

ansr2510@gmail.com, s.gorthi@iittp.ac.in

Acknowledgment: This research has received partial support through project grant number 2022-IRP-26694272 from the Semiconductor Research Corporation (SRC) under the India Research Program (IRP).

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Introduction

Why low dose CT?

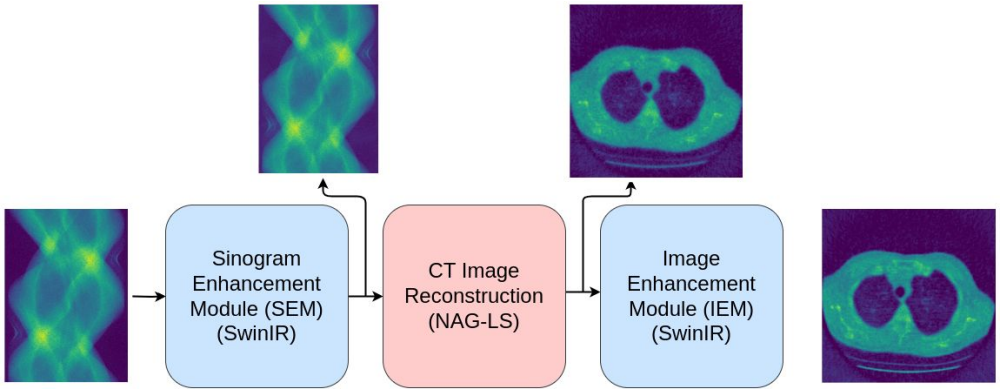
Context

- Reduced radiation exposure
- Repeated screenings -> Early detection -> Better patient Outcomes
- Cost-Effective
- Shorter scan time -> Better patient comfort -> Patient compliance
- Patient safety

Problem

- Reduced image quality i.e lower signal-to-noise ratio
- Limited diagnostic information
- False positives and negatives -> Unnecessary follow-up procedure
- Applicability to specific conditions
- Risk-Benefit considerations

Method



SEM

- To reduce noise and artifacts present in the sinogram
- Impacts the quality of the reconstructed CT images

NAG-LS [*]

- NAG to solve the least squares problem in CT image reconstruction

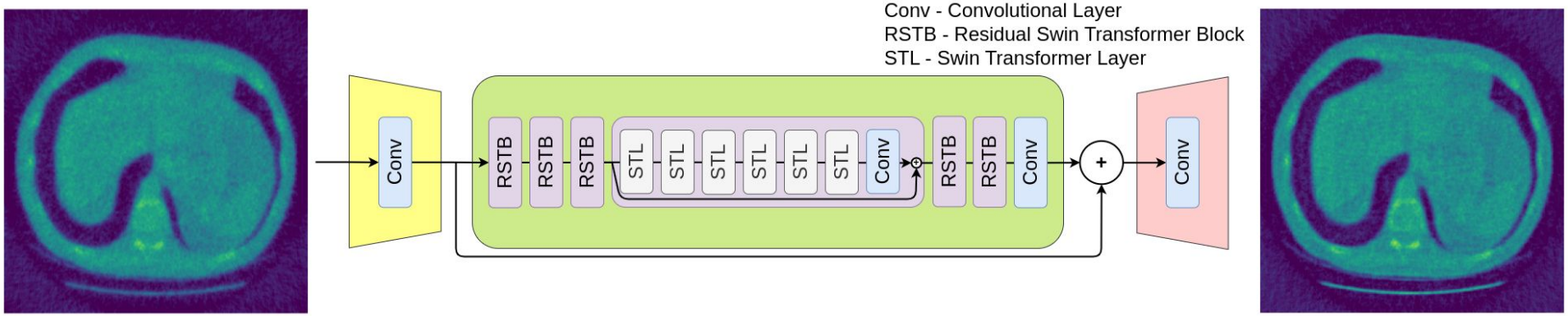
$$\min_{x \in \mathbb{R}^{n \times m \times p}} f(x) = \frac{1}{2} \left\| Ax - b \right\|_2^2$$

IEM

- To preserve fine details and improve overall image quality
- Fine tunes the image, making it diagnostically valuable

★ Nesterov, Y. (2013). *Introductory lectures on convex optimization: A basic course* (Vol. 87). Springer Science & Business Media.

Method



SwinIR [*]

- Shallow feature extraction module: uses a convolution layer
- Deep feature extraction module: RSTB blocks (uses several Swin Transformer layers for local attention and cross-window interaction)
- Convolution layer at the end of DFE and a residual connection
- Image reconstruction module: uses a convolution layer
- MSE loss criterion, Adam optimizer, StepLR scheduler used during training

★ Liang, J., Cao, J., Sun, G., Zhang, K., Van Gool, L., & Timofte, R. (2021). Swinir: Image restoration using swin transformer. In *Proceedings of the IEEE/CVF international conference on computer vision* (pp. 1833-1844).

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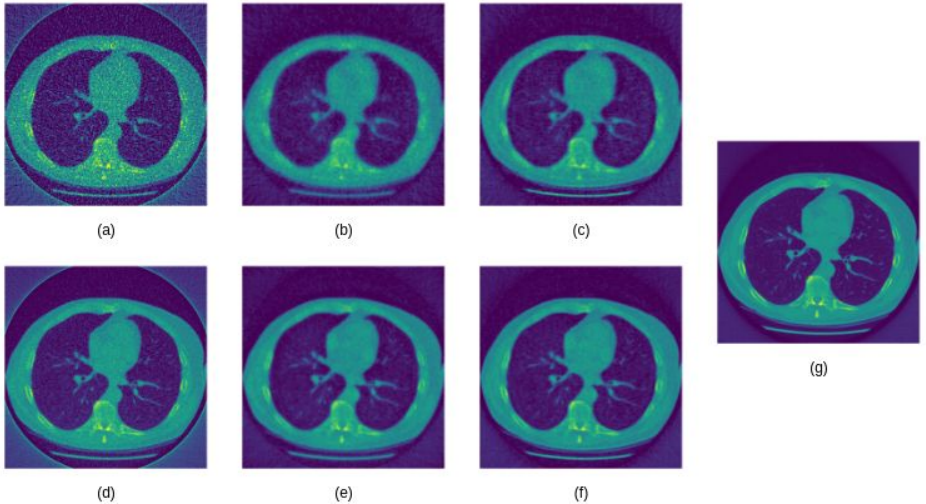
Experiment

Method	Low dose	Clinical dose
FDK [*]	0.07959	0.03102
SIRT	0.06648	0.04545
NAG-LS	0.04408	0.04070
NAG-LS+SEM	0.01520	0.00940
NAG-LS+SEM+IEM	**0.00918**	**0.00467**



- Clinical dose, FDK outperforms NAG-LS
- Clinical dose, when SEM is used NAG-LS outperformed FDK again
- SEM reduced MSE but blurred image
- IEM accentuated sharp features

- (a), (d): FDK (Baseline)
- (b), (e): NAG-LS with SEM
- (c), (f): NAG-LS with SEM and IEM
- (g): Clean CT image
- Upper row: Low dose, Lower row: Clinical dose

★ Feldkamp, L. A., Davis, L. C., & Kress, J. W. (1984). Practical cone-beam algorithm. *Josa a*, *1*(6), 612-619.

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Conclusion

End to End Training (Soon)
To integrate and optimize all the components of the reconstruction pipeline

Summary

1. Significantly reduced MSE, in the case of low dose by one-fifth and clinical dose by one-tenth
2. Among the top 5 solutions