



# Models Genesis: Generic Autodidactic Models for 3D Medical Image Analysis

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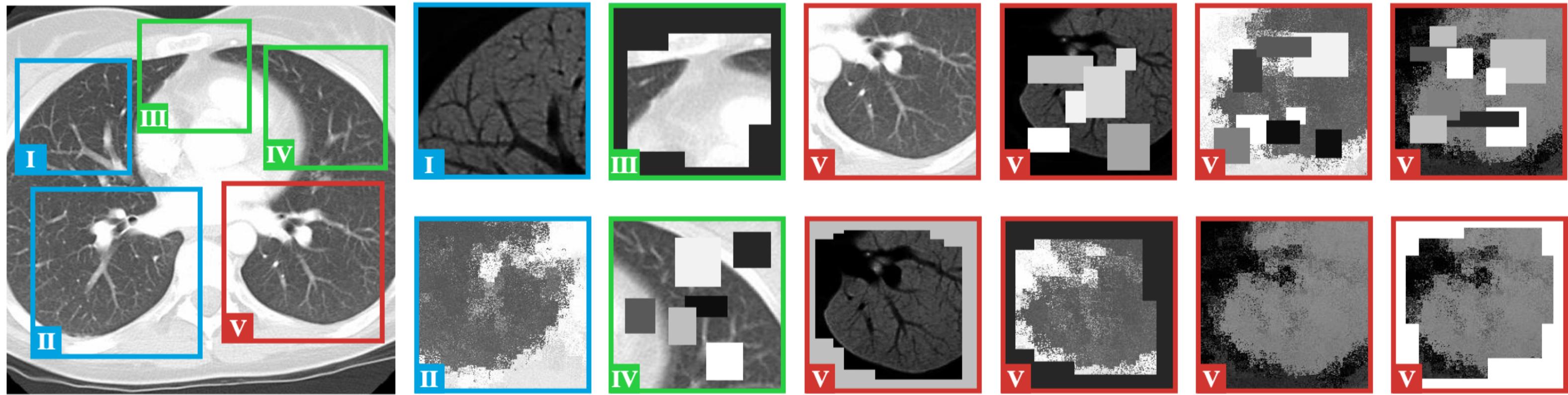
<https://arxiv.org/abs/1908.06912>

MICCAI Young Scientist Award 2019

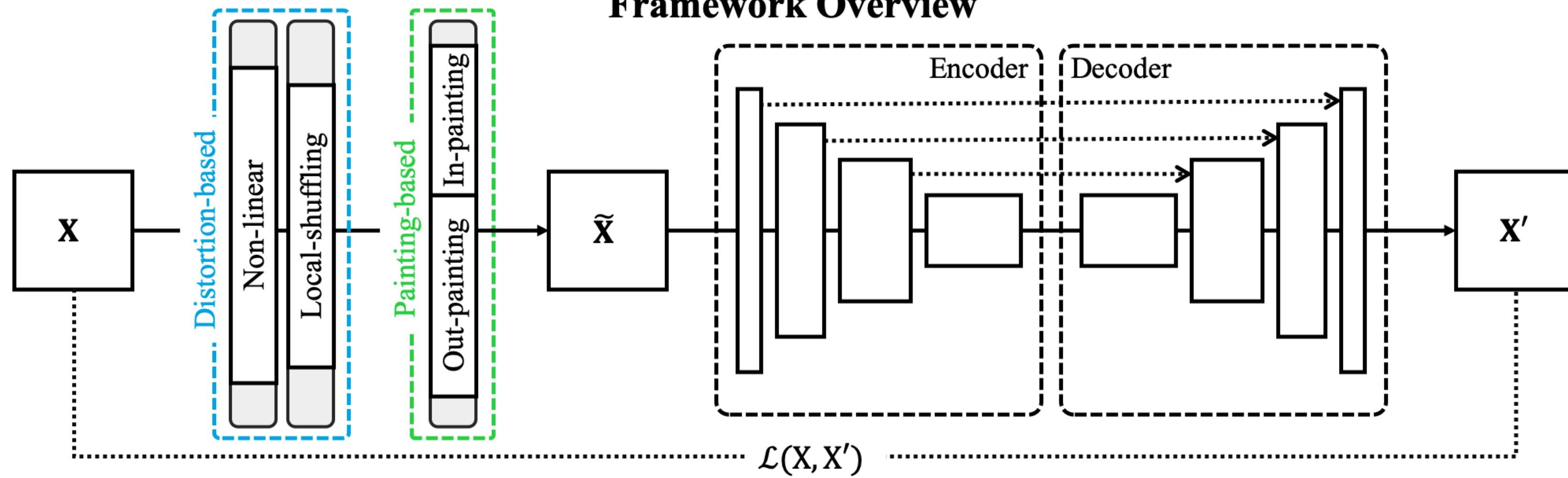


# Model Arch

Genesis Chest CT 2D

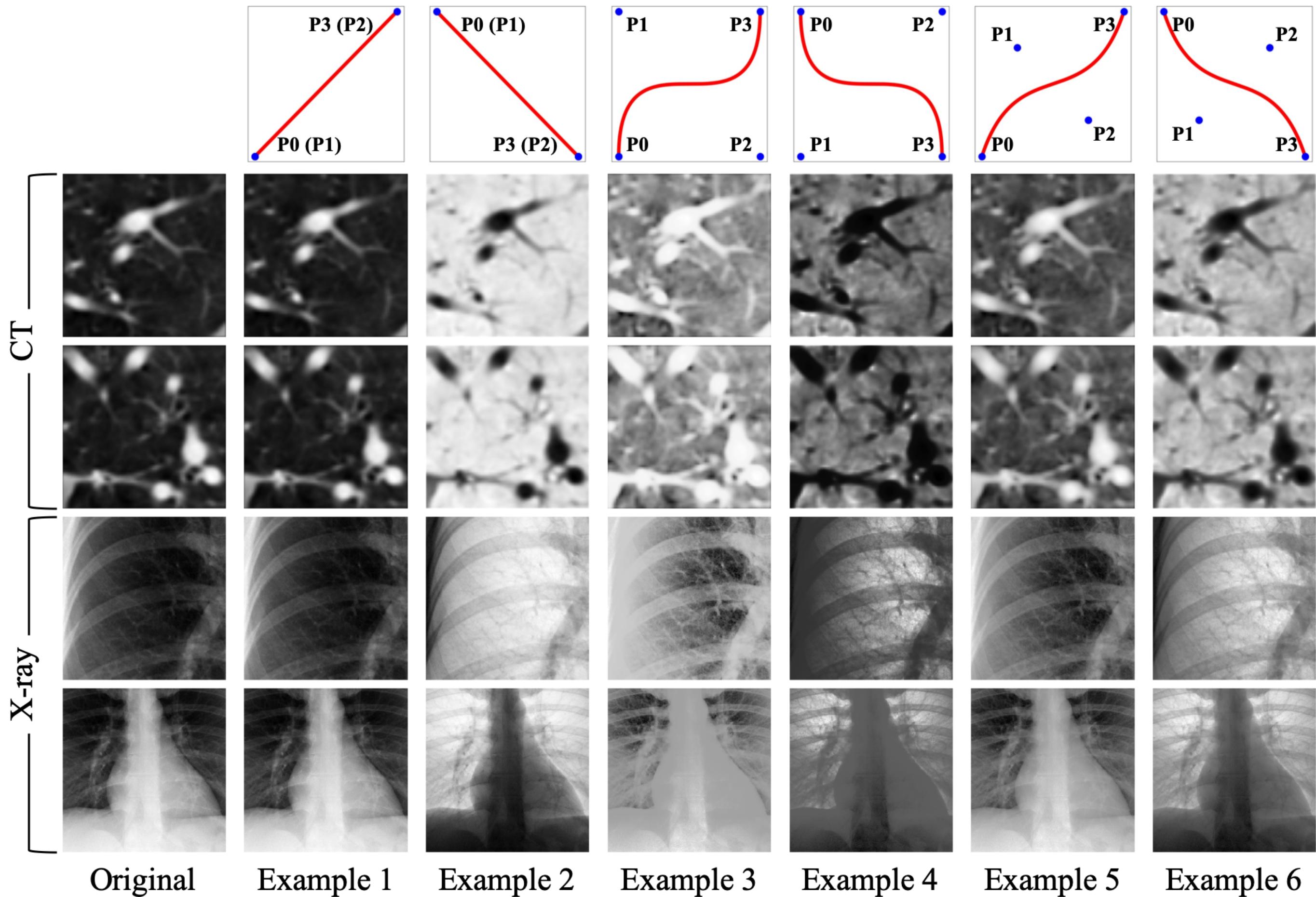


Framework Overview





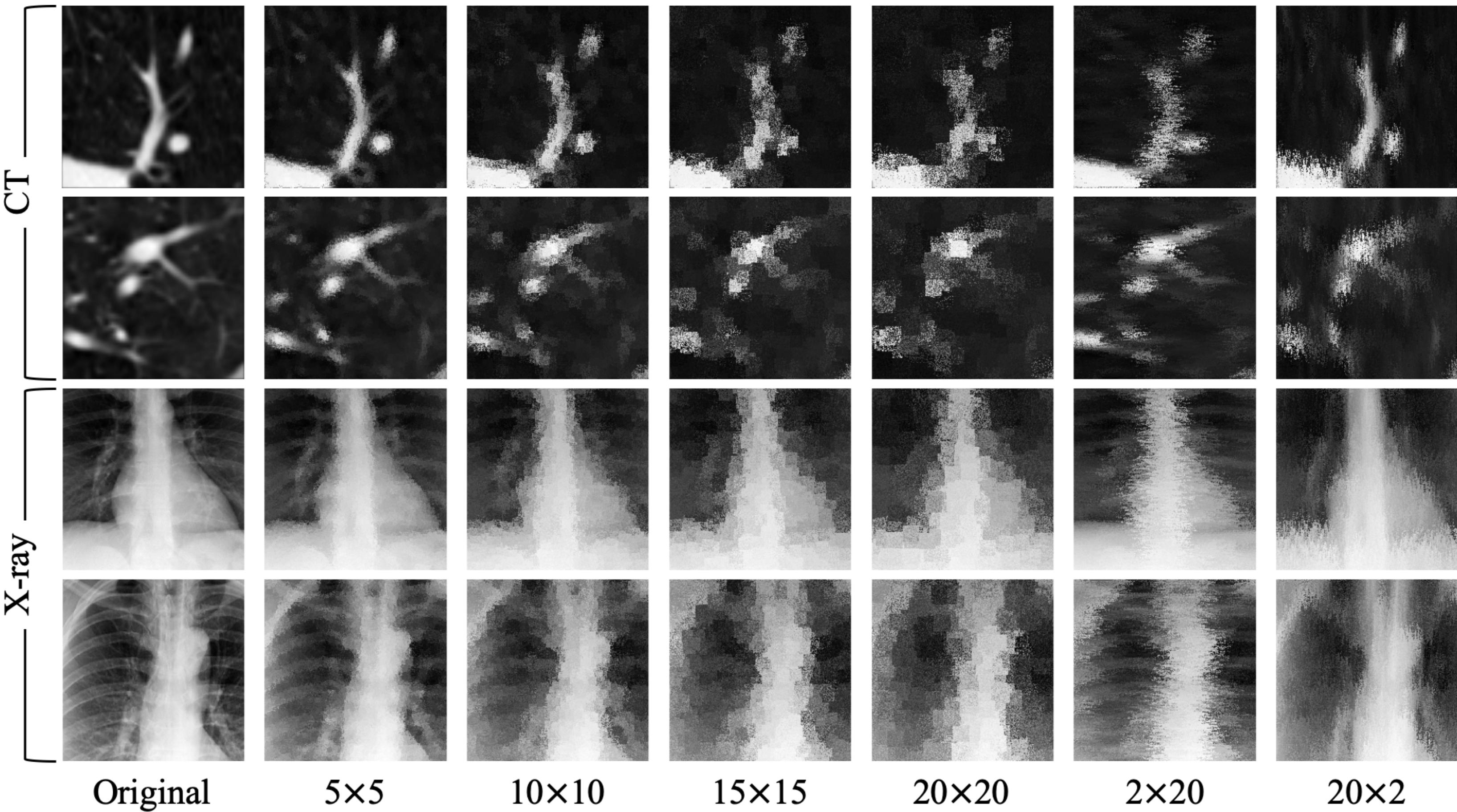
# Non-linear Transform



$$B(t) = (1-t)^3 P_0 + 3(1-t)^2 t P_1 + 3(1-t)t^2 P_2 + t^3 P_3, \quad t \in [0, 1],$$



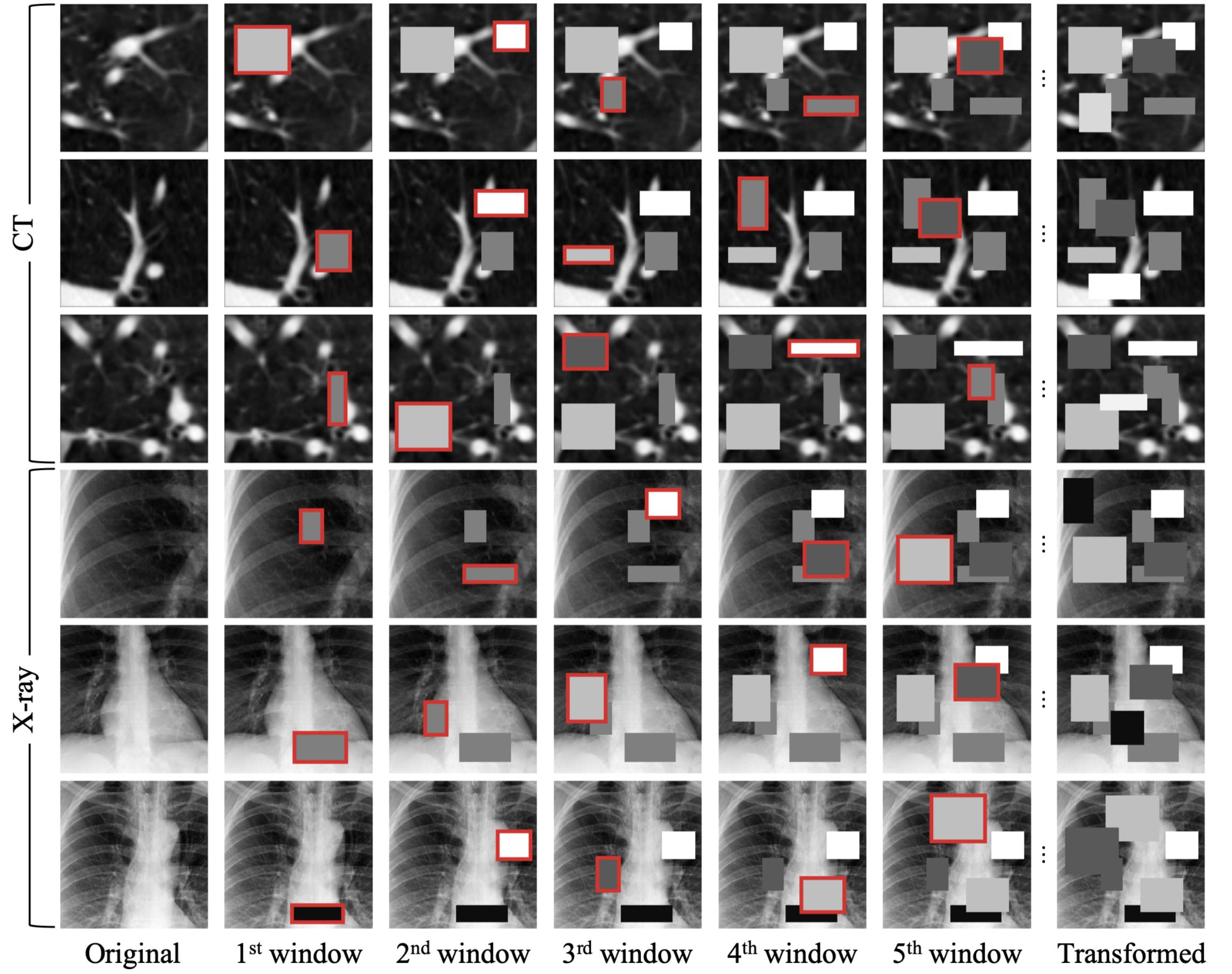
# Local Pixel Shuffling



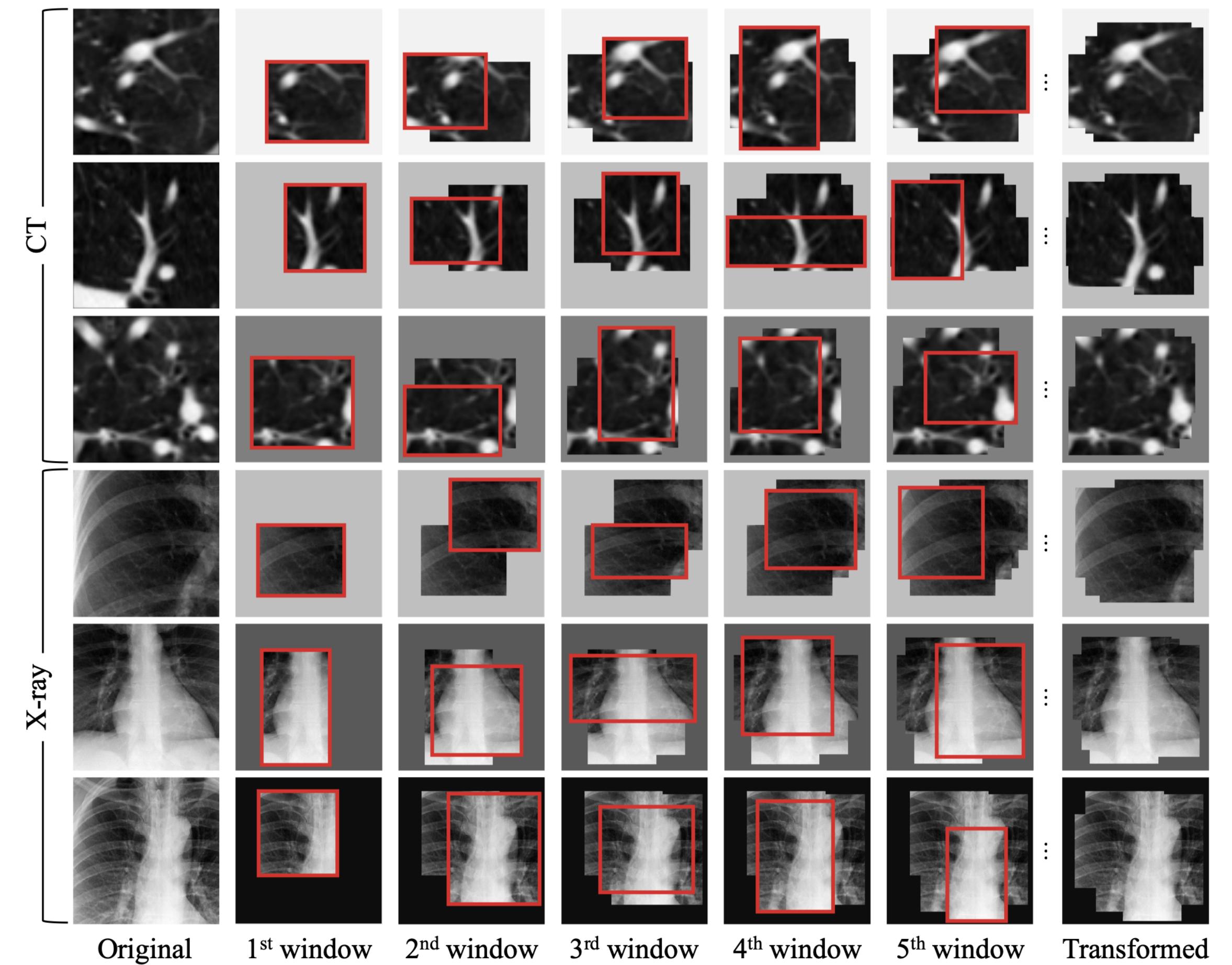
$$\tilde{\mathbf{W}} = \mathbf{P} \times \mathbf{W} \times \mathbf{P}',$$



# In-painting

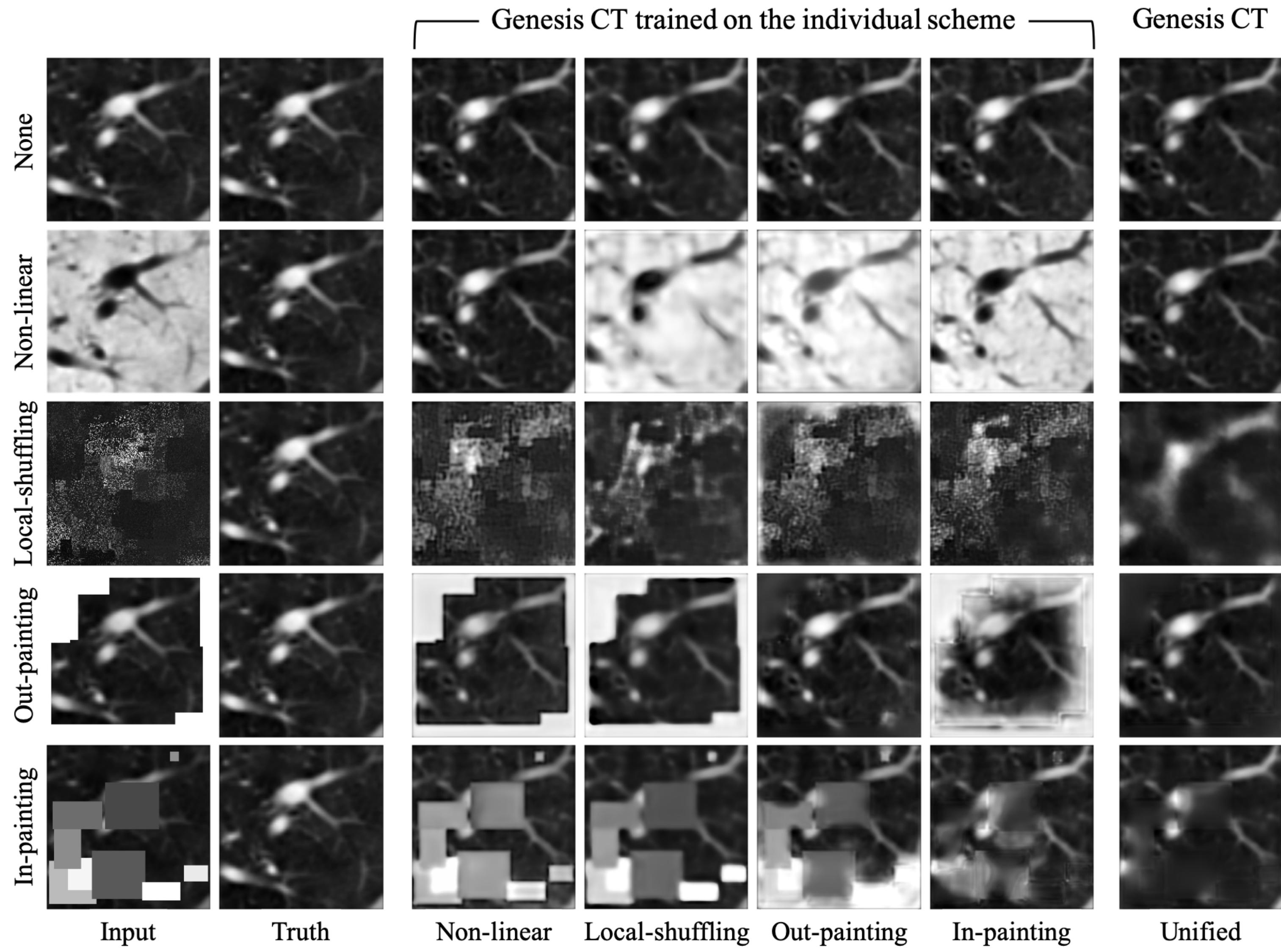


# Out-painting

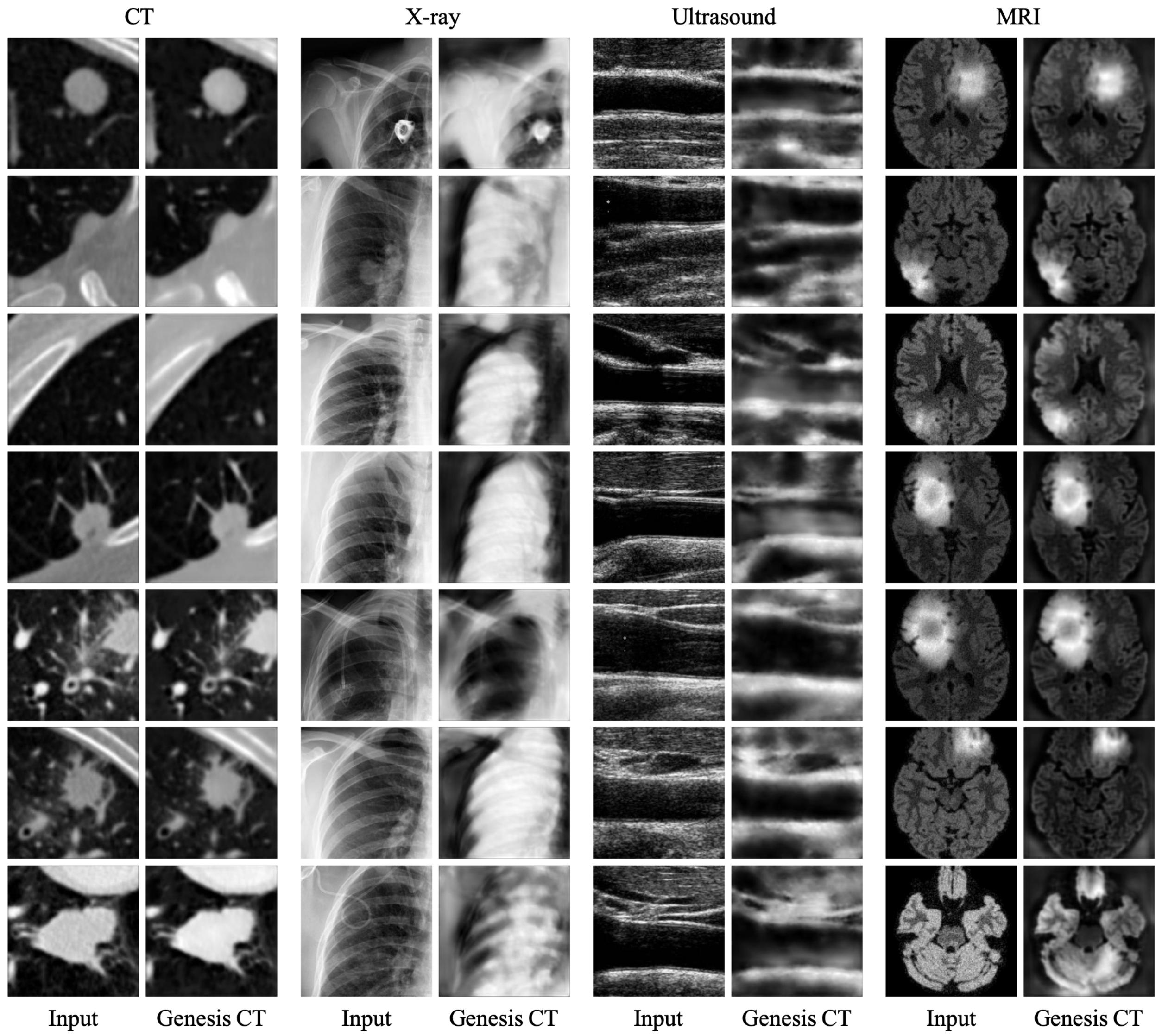




# Sample Outputs (training)



# Sample Domain Crossing





# Experiment Results

Task	Metric	Disease	Organ	Dataset	Modality	Scratch (%)	Genesis (%)	p-value
NCC <sup>1</sup>	AUC					94.25 $\pm$ 5.07	<b>98.20<math>\pm</math>0.51</b>	0.0180
NCS <sup>2</sup>	IoU					74.05 $\pm$ 1.97	<b>77.62<math>\pm</math>0.64</b>	1.04e-4
ECC <sup>3</sup>	AUC	<b>X</b>	<b>X</b>			79.99 $\pm$ 8.06	<b>88.04<math>\pm</math>1.40</b>	0.0058
LCS <sup>4</sup>	IoU	<b>X</b>	<b>X</b>	<b>X</b>		74.60 $\pm$ 4.57	<b>79.52<math>\pm</math>4.77</b>	0.0361
BMS <sup>5</sup>	IoU	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	90.16 $\pm$ 0.41	<b>90.60<math>\pm</math>0.20</b>	0.0041

<sup>1</sup> LUNA winner holds an official score of 0.968 vs. 0.971 (ours)

<sup>2</sup> Wu *et al.* holds a Dice of 74.05% vs. 75.86% $\pm$ 0.90% (ours)

<sup>3</sup> Zhou *et al.* holds an AUC of 87.06% vs. 88.04% $\pm$ 1.40% (ours)

<sup>4</sup> LiTS winner w/ postprocessing (PP) holds a Dice of 96.60% vs. 91.13% $\pm$ 1.51% (ours w/o PP)

<sup>5</sup> BraTS winner w/ ensembling holds a Dice of 91.00% vs. 92.58% $\pm$ 0.30% (ours w/o ensembling)

Approach	NCC (%)	NCS (%)	ECC (%)	LCS (%)	BMS (%)
Scratch	94.25 $\pm$ 5.07	74.05 $\pm$ 1.97	79.99 $\pm$ 8.06	74.60 $\pm$ 4.57	90.16 $\pm$ 0.41
Distortion (ours)	96.46 $\pm$ 1.03	77.08 $\pm$ 0.68	<b>88.04<math>\pm</math>1.40</b>	79.08 $\pm$ 4.26	<b>90.60<math>\pm</math>0.20</b>
Painting (ours)	<b>98.20<math>\pm</math>0.51</b>	77.02 $\pm$ 0.58	87.18 $\pm$ 2.72	78.62 $\pm$ 4.05	90.46 $\pm$ 0.21
Unified (ours)	97.90 $\pm$ 0.57	<b>77.62<math>\pm</math>0.64</b>	87.20 $\pm$ 2.87	<b>79.52<math>\pm</math>4.77</b>	90.59 $\pm$ 0.21
p-value	0.0848	0.0520	0.2102	0.4249	0.4276

Table 1: Target tasks.

Code <sup>†</sup>	Object	Modality	Source	Description
NCC	Lung Nodule	CT	LUNA2016	Lung nodule false positive reduction
NCS	Lung Nodule	CT	LIDC-IDRI	Lung nodule segmentation
ECC	Pulmonary Embolism	CT	PE-CAD	Pulmonary embolism false positive reduction
LCS	Liver	CT	LiTS2017	Liver segmentation
DXC	Pulmonary Diseases	X-ray	ChestX-ray8	Eight pulmonary diseases classification
IUC	CIMT RoI	Ultrasound	UFMCAEL	RoI, bulb, and background classification
BMS	Brain Tumor	MRI	BraTS2013	Brain tumor segmentation

<sup>†</sup> The first letter denotes the object of interest (“N” for lung nodule, “E” for pulmonary embolism, “L” for liver, etc); the second letter denotes the modality (“C” for CT, “X” for X-ray, “U” for Ultrasound, etc); the last letter denotes the task (“C” for classification, “S” for segmentation).

Task	2D (%)			3D (%)			p-value <sup>†</sup>
	Scratch	ImageNet	Genesis	Scratch	ImageNet	Genesis	
NCC	96.03 $\pm$ 0.86	<b>97.79<math>\pm</math>0.71</b>	97.45 $\pm$ 0.61	94.25 $\pm$ 5.07	N/A	<b>98.20<math>\pm</math>0.51</b>	0.0213
NCS	70.48 $\pm$ 1.07	72.39 $\pm$ 0.77	72.20 $\pm$ 0.67	74.05 $\pm$ 1.97	N/A	<b>77.62<math>\pm</math>0.64</b>	<1e-8
ECC	71.27 $\pm$ 4.64	78.61 $\pm$ 3.73	78.58 $\pm$ 3.67	79.99 $\pm$ 8.06	N/A	<b>88.04<math>\pm</math>1.40</b>	5.50e-4

<sup>†</sup>These p-values are calculated between our Models Genesis vs. the fine-tuning from ImageNet, which always offers the best performance (highlighted in red) for all three tasks in 2D.