GL-LCM: Global-Local Latent Consistency Models for Fast High-Resolution Bone Suppression in Chest X-Ray Images

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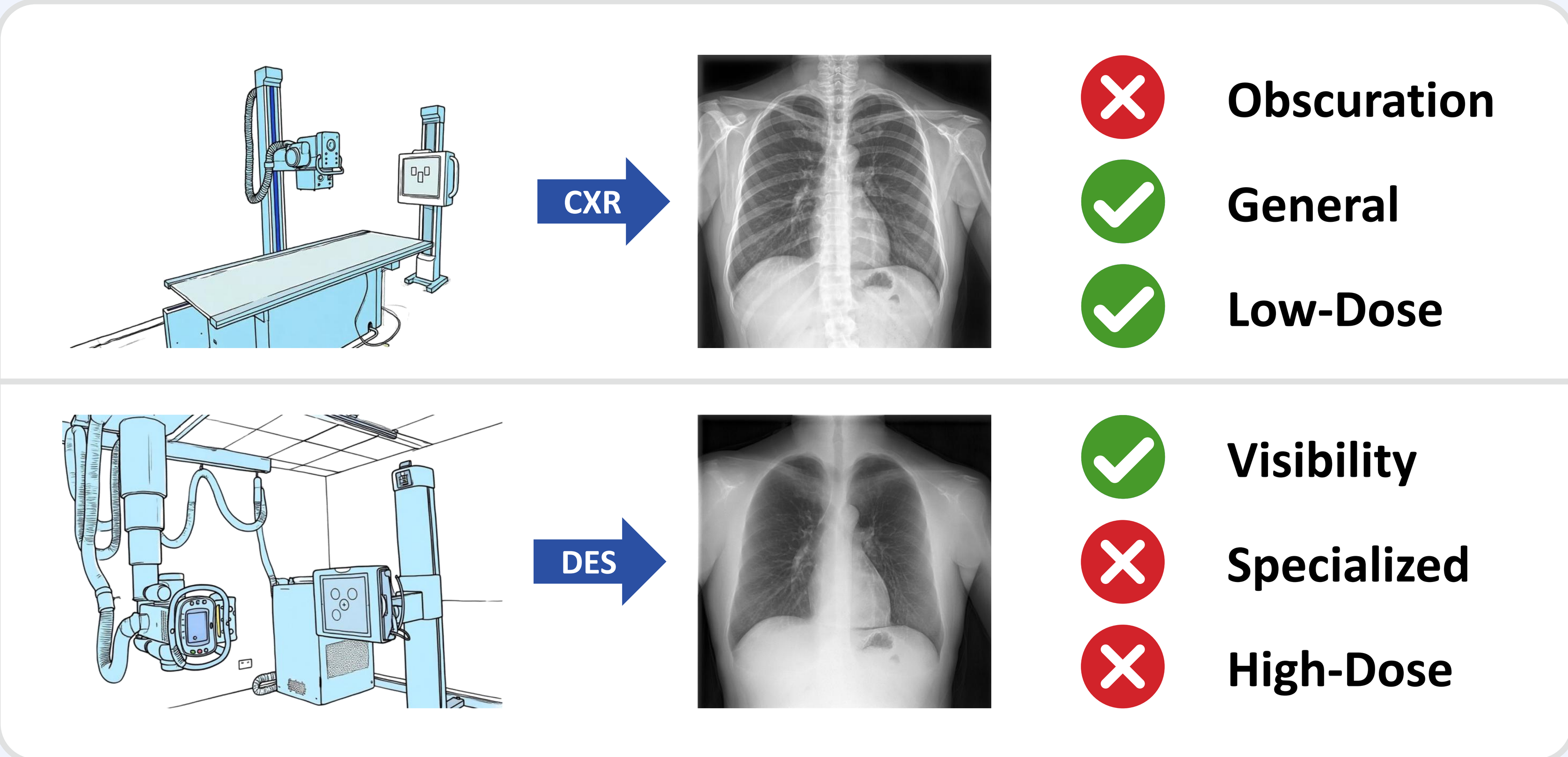
MICCAI2025 Daejeon REPUBLIC OF KOREA

INTRODUCTION

Chest X-Ray (CXR) imaging for pulmonary diagnosis raises significant challenges, primarily because **bone structures can obscure critical details** necessary for accurate diagnosis. By utilizing two X-ray exposures at different energy levels, **Dual-Energy Subtraction (DES)** effectively reduces the visual clutter caused by overlapping bones. However, DES imaging requires **specialized equipment** and increases **radiation exposure**, making it less accessible and impractical in resource-limited settings.



Our goal: To enable fast high-resolution bone suppression via GL-LCM.

CHALLENGES

1. **Failure to balance** global bone suppression and local detail retention.
2. **High computational demand** leading to excessive processing time.

QUANTITATIVE RESULTS

Table 1. Comparison of different methods on the SZCH-X-Rays dataset.

Method	BSR (%) ↑	MSE (10^{-3}) ↓	PSNR ↑	LPIPS ↓
VAE	91.281 ± 3.088	1.169 ± 1.059	30.018 ± 2.007	0.237 ± 0.047
VQ-VAE	94.485 ± 2.407	0.645 ± 0.596	32.600 ± 2.071	0.137 ± 0.029
VQGAN	94.330 ± 3.402	0.923 ± 2.478	32.096 ± 2.420	0.083 ± 0.020
Gusarev *et al.*	94.142 ± 2.666	1.028 ± 2.201	31.369 ± 22.385	0.156 ± 0.031
MCA-Net	95.442 ± 2.095	0.611 ± 0.435	32.689 ± 1.939	0.079 ± 0.018
ResNet-BS	94.508 ± 1.733	0.646 ± 0.339	32.265 ± 1.635	0.107 ± 0.022
Wang *et al.*	89.767 ± 6.079	1.080 ± 0.610	29.963 ± 1.378	0.072 ± 0.016
BS-Diff	92.428 ± 3.258	0.947 ± 0.510	30.627 ± 1.690	0.212 ± 0.041
BS-LDM	94.159 ± 2.751	0.701 ± 0.293	31.953 ± 1.969	0.070 ± 0.018
GL-LCM (Ours)	95.611 ± 1.529	0.512 ± 0.293	33.347 ± 1.829	0.056 ± 0.015

Table 2. Inference efficiency comparison on the SZCH-X-Rays dataset.

Method	Sampler	Sampling Steps	Parameters (M)	Inference Time (s)
BS-Diff	DDPM	1000	254.7	108.86
BS-LDM	DDPM	1000	421.3	84.62
GL-LCM (Ours)	LCM	50	436.9	8.54

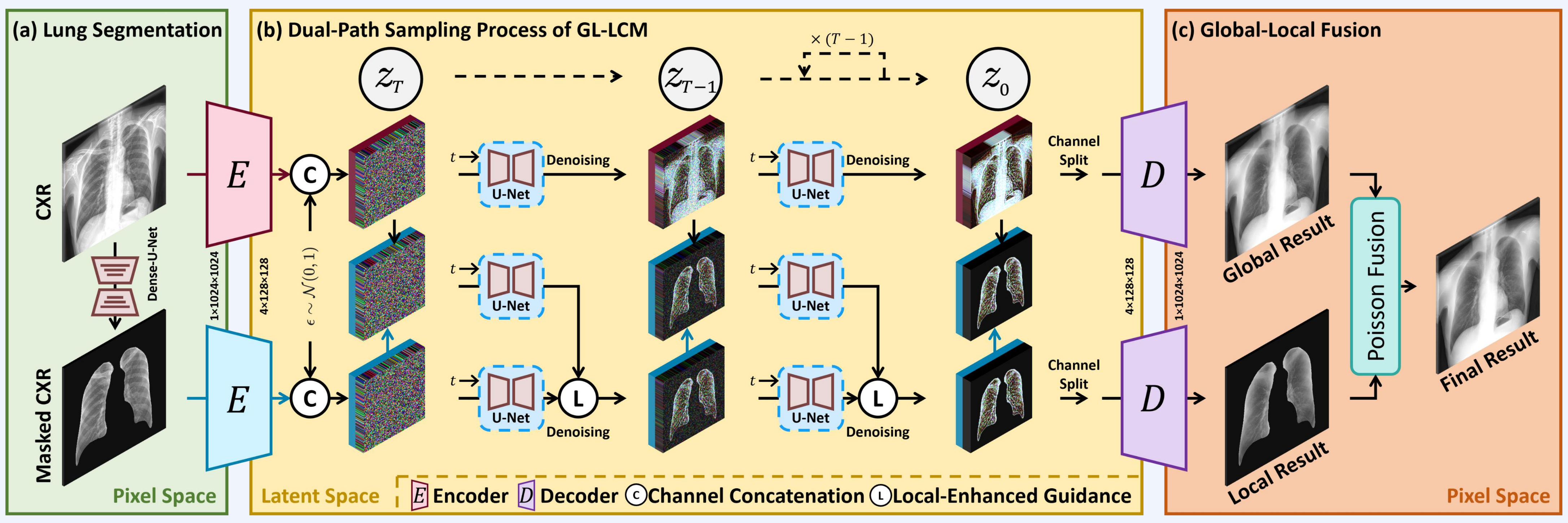
Table 3. Effect of conditional guidance methods for local-path sampling.

Guidance Method	SZCH-X-Rays		JSRT	
	PSNR ↑	LPIPS ↓	PSNR ↑	LPIPS ↓
Vanilla Guidance	32.777 ± 2.091	0.058 ± 0.016	32.296 ± 3.454	0.073 ± 0.020
CFG	32.315 ± 1.717	0.068 ± 0.013	32.613 ± 3.604	0.070 ± 0.015
LEG (Ours)	33.347 ± 1.829	0.056 ± 0.015	32.951 ± 3.799	0.052 ± 0.015

Table 4. Effect of fusion strategies on the SZCH-X-Rays and JSRT datasets.

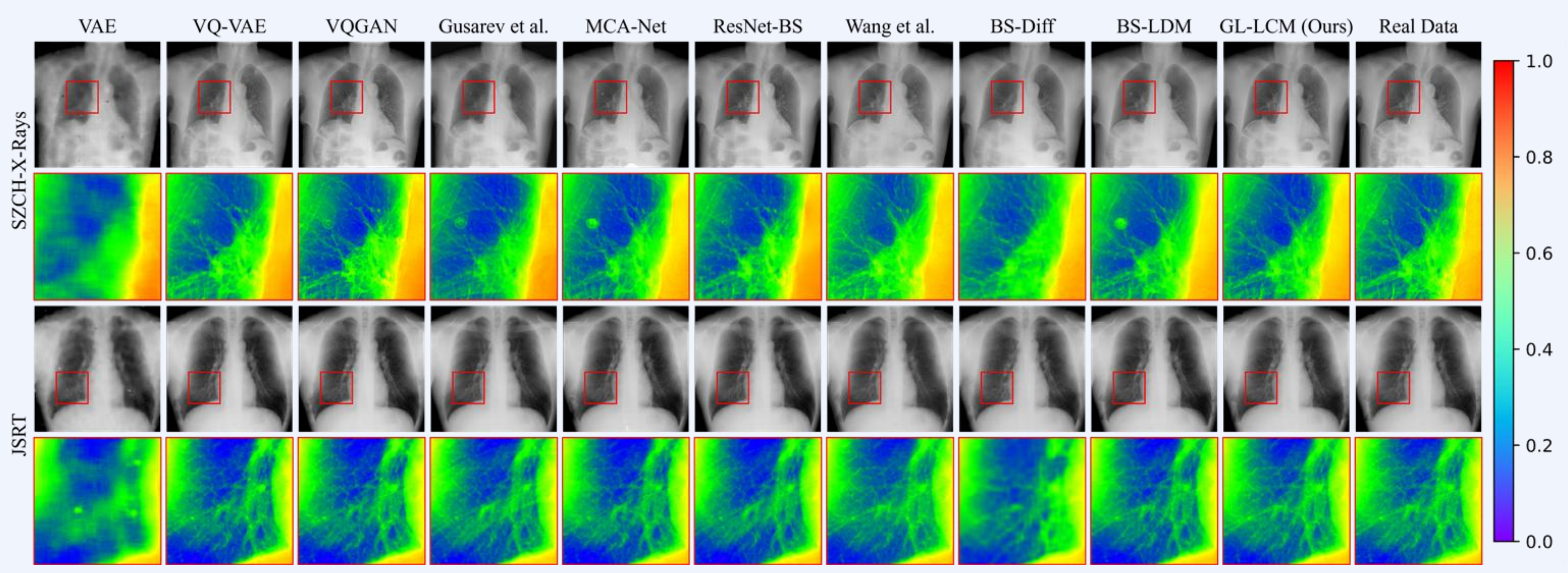
Fusion Strategy	SZCH-X-Rays		JSRT	
	PSNR ↑	LPIPS ↓	PSNR ↑	LPIPS ↓
×	31.360 ± 2.079	0.091 ± 0.020	31.638 ± 3.078	0.074 ± 0.021
α-Fusion	29.781 ± 1.522	0.181 ± 0.021	31.784 ± 3.043	0.092 ± 0.013
AE Fusion	30.850 ± 1.806	0.141 ± 0.028	31.835 ± 3.075	0.061 ± 0.017
Poisson Fusion (Ours)	33.347 ± 1.829	0.056 ± 0.015	32.951 ± 3.799	0.052 ± 0.015

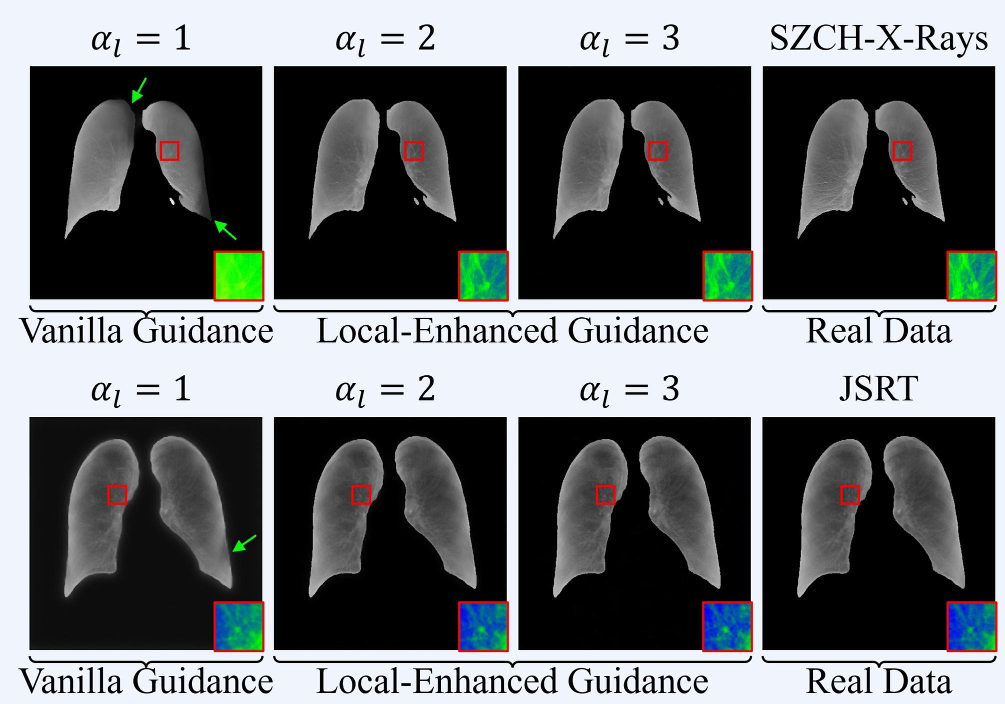
METHOD



1. **Dual-path sampling** and **global-local fusion** facilitate **bone suppression** while retaining **texture details**.
2. GL-LCM significantly enhances **inference efficiency** (**10%** of current diffusion-based) via **LCM sampling**.
3. We introduce **Local-Enhanced Guidance (LEG)** to mitigate **boundary artifacts** and **detail blurring** in local-path sampling **without additional training**.
4. **Comprehensive experiments** on SZCH-X-Rays and JSRT demonstrate **exceptional performance**.

QUALITATIVE RESULTS





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