

MAM-E: Mammographic synthetic image generation with diffusion models

Ricardo Montoya-del-Angel¹, Robert Martí¹

¹Computer Vision and Robotics (VICOROB) Institute, University of Girona, Girona, Spain



Motivation

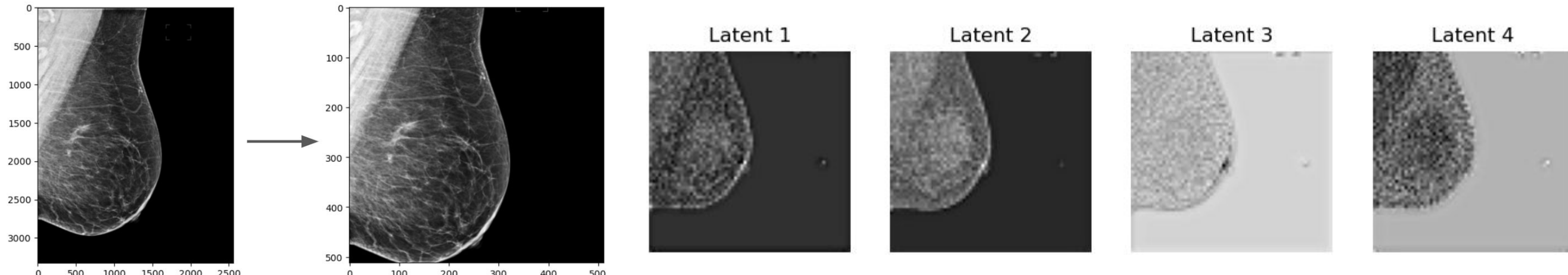
- Generative models are used as a data augmentation technique for the **data scarcity problem** faced in the medical imaging field.
- The implementation of diffusion models for medical images is currently at early stages, specially for mammography.
- We propose exploring the use of diffusion models for the generation of high quality full-field digital mammograms using state-of-the-art **conditional diffusion models**. We also propose using stable diffusion models for the **inpainting of synthetic lesions** on healthy mammograms.

Methods

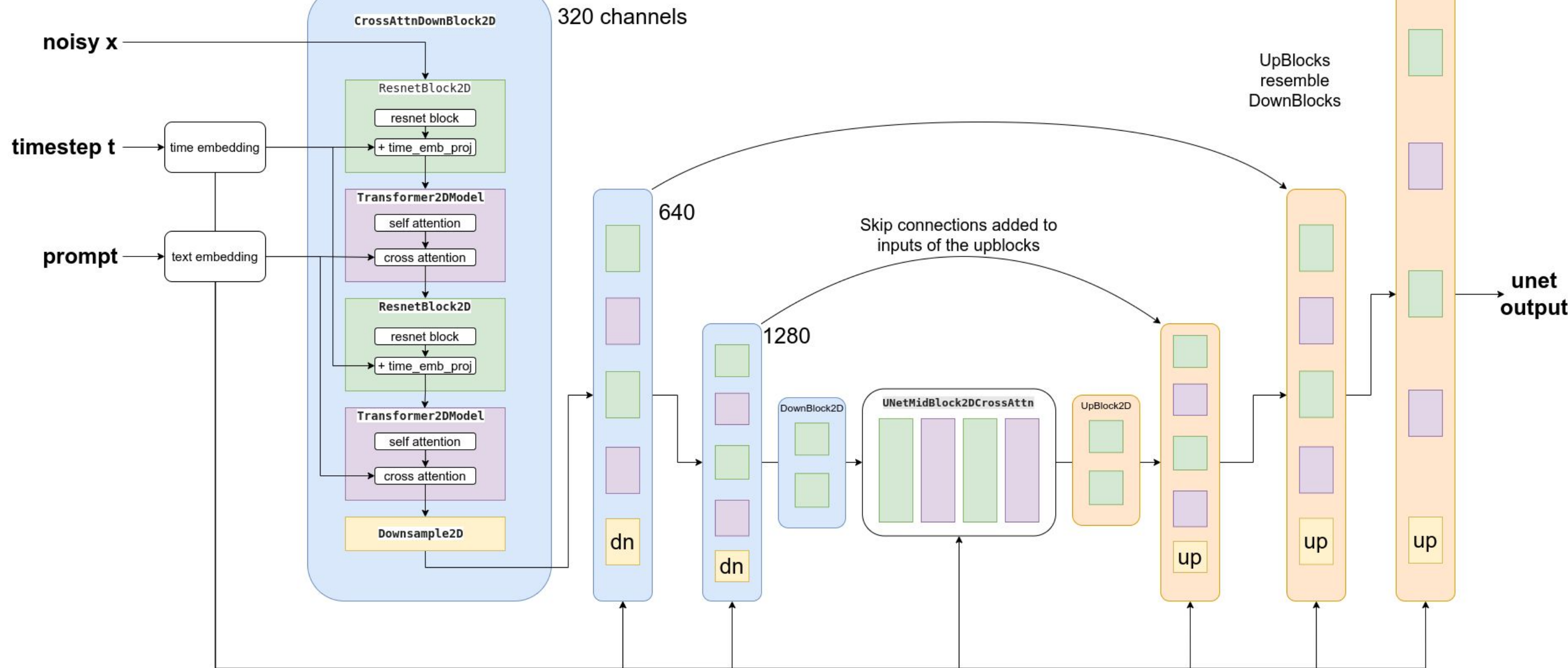
— Training
— Inference

Dataset and preprocessing

	OMI-H	VinDr	Combined
Healthy	33,643	13,942	47,585
With lesion	6,908	1,533	8,441
Total	40,551	15,475	56,026



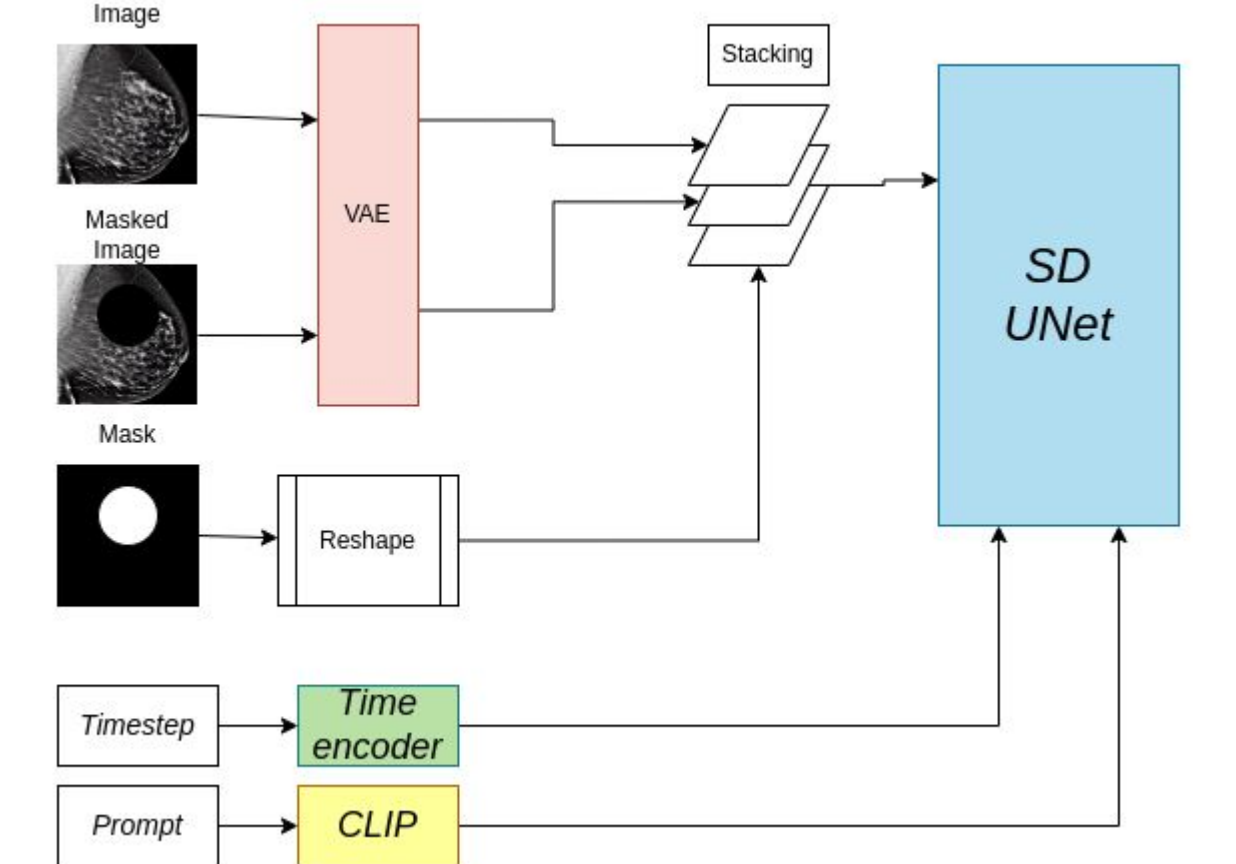
Stable diffusion



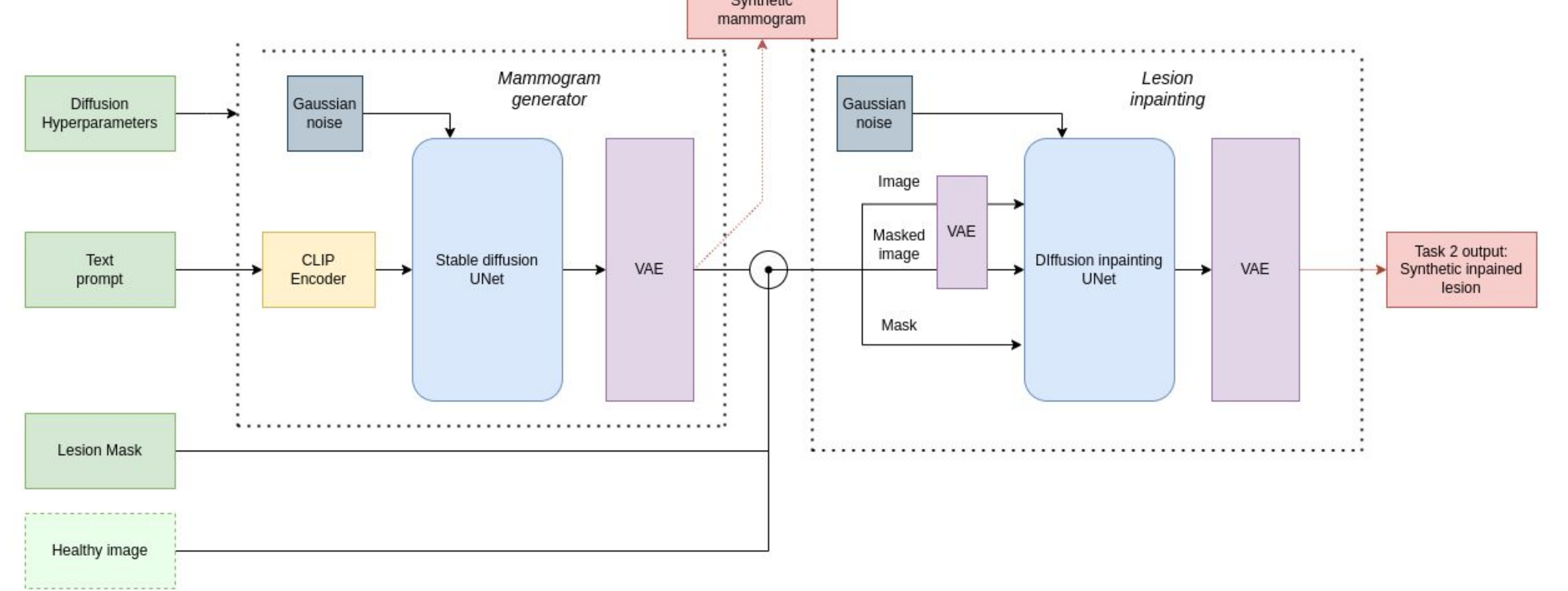
Stable Diffusion training algorithm

- Sample a batch of images $x_0 \sim q(x_0)$
- Encode x_0 into the latent space
- Sample a random timestep from a uniform distribution $t \sim U(1, \dots, T)$
- Sample random Gaussian noise from a normal distribution $\epsilon \sim N(0, I)$
- Create x_t by adding noise to the batch images x_0 using the noise ϵ and timestep t .
- Take an optimization step in the direction of the gradient $\nabla_{\theta} ||\epsilon - \epsilon_{\theta}(x_t, t)||$

Inpainting pipeline

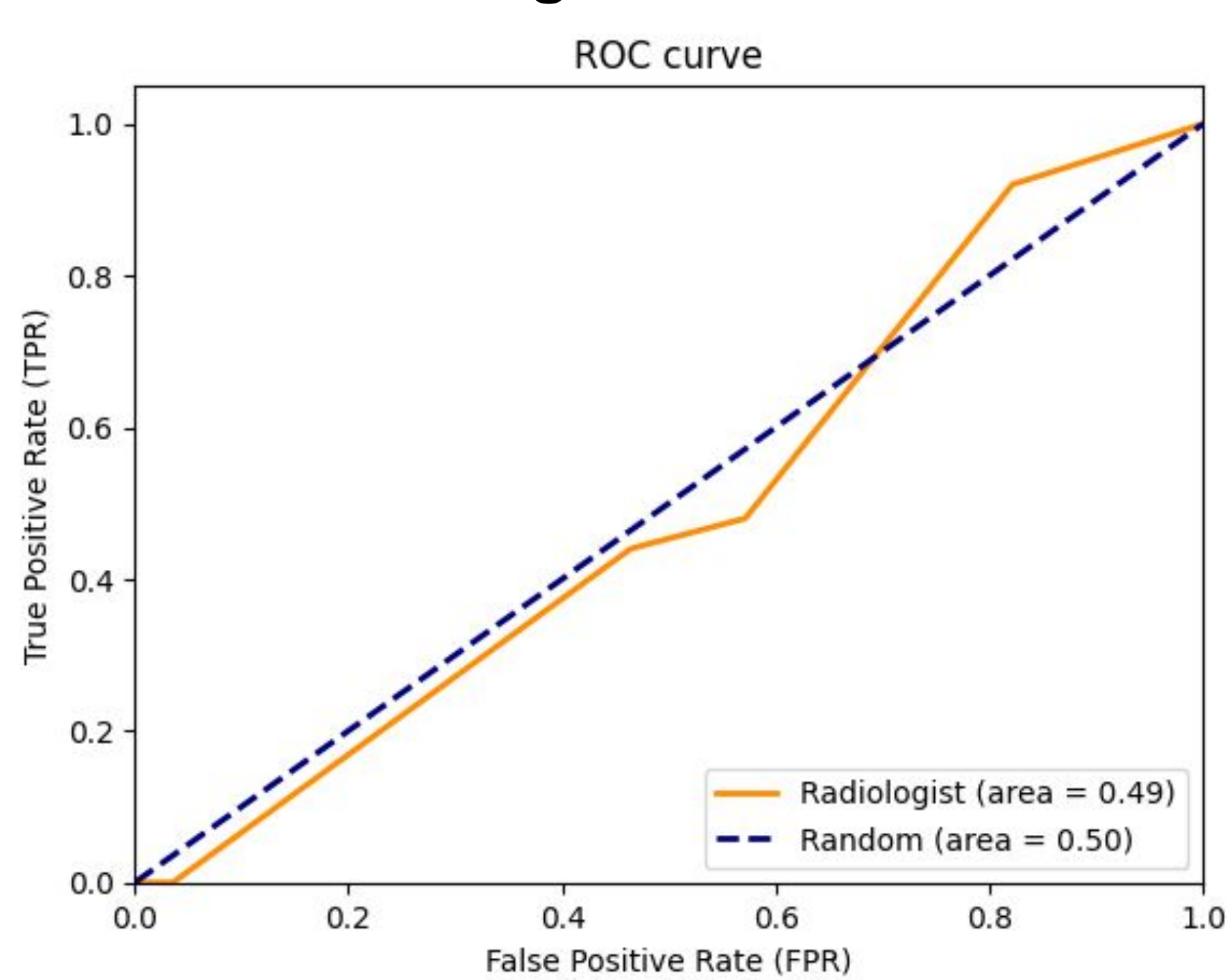


MAM-E pipeline



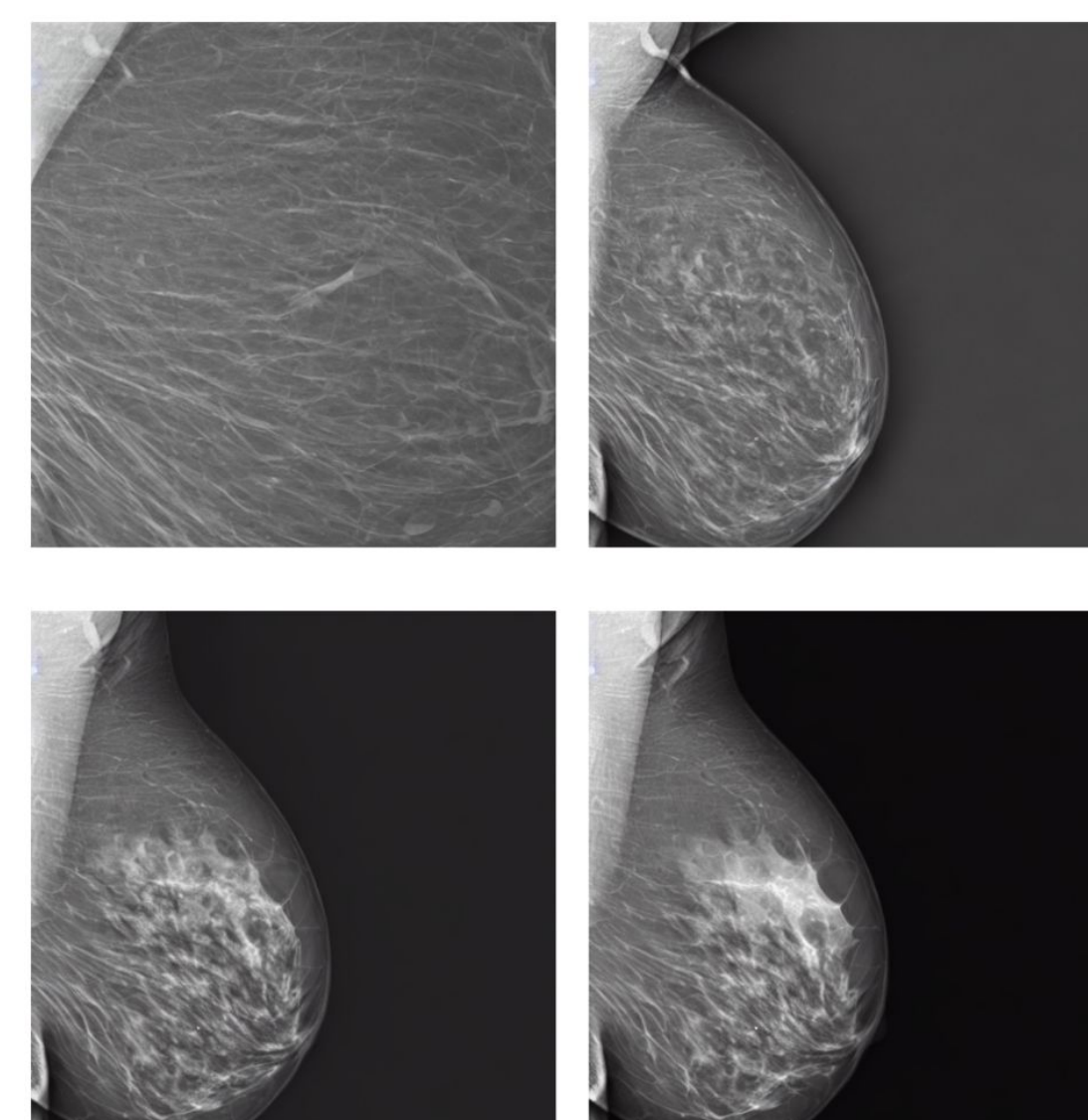
Results

Radiologist assessment

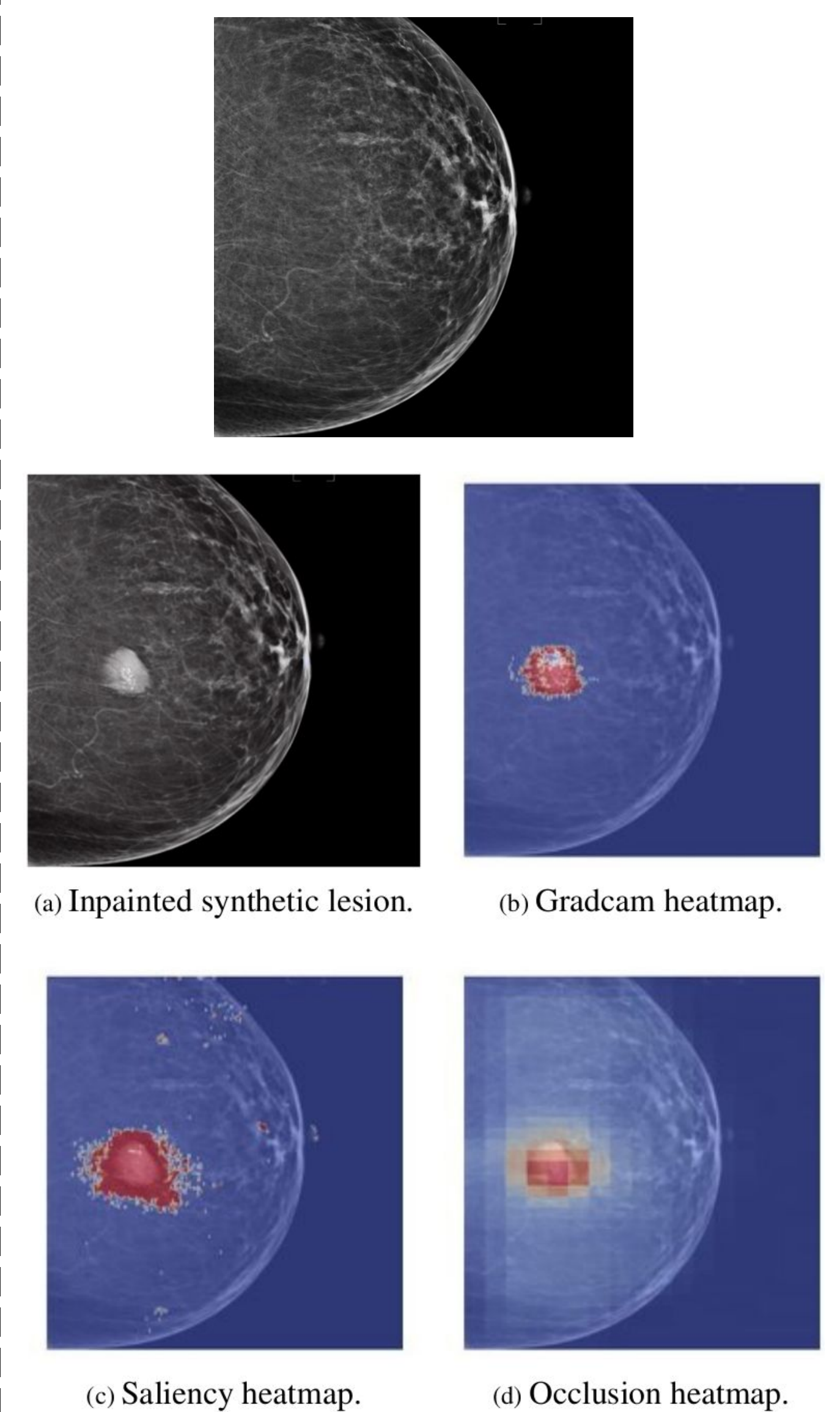


Guidance effect

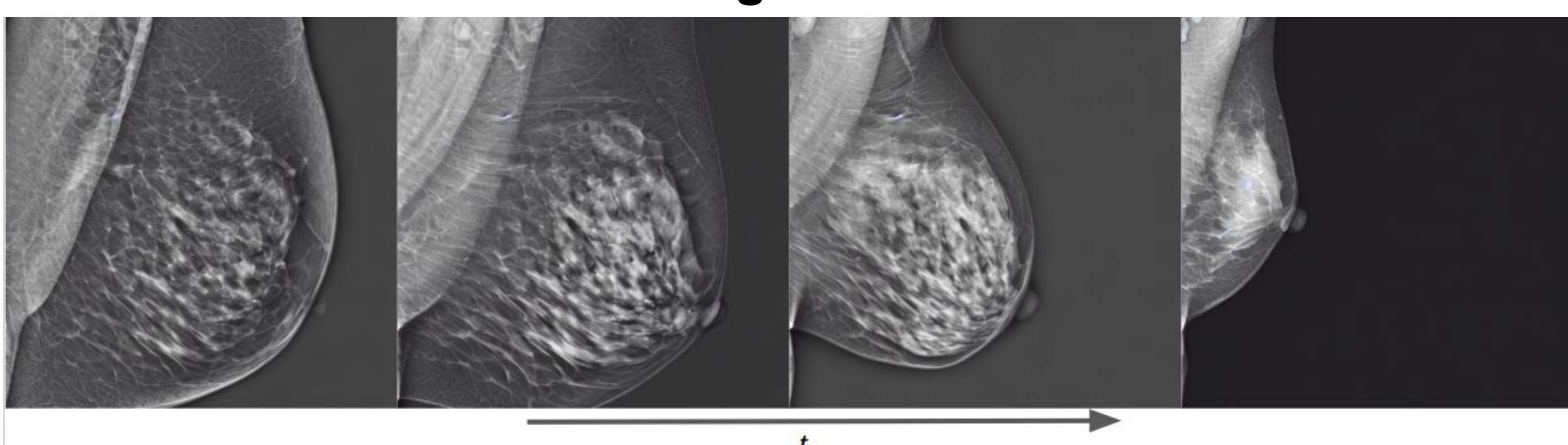
	Hologic		Siemens	
Guidance	Mean↓	STD	Mean↓	STD
4	0.29	0.16	0.38	0.19
5	0.34	0.16	0.36	0.17
6	0.38	0.12	0.41	0.17
7	0.38	0.1	0.34	0.17
8	0.43	0.11	0.42	0.2
9	0.42	0.13	0.43	0.16
10	0.49	0.12	0.41	0.13
11	0.5	0.12	0.47	0.17
12	0.52	0.11	0.46	0.16
13	0.48	0.1	0.42	0.16
14	0.5	0.11	0.4	0.18



Lesion generation

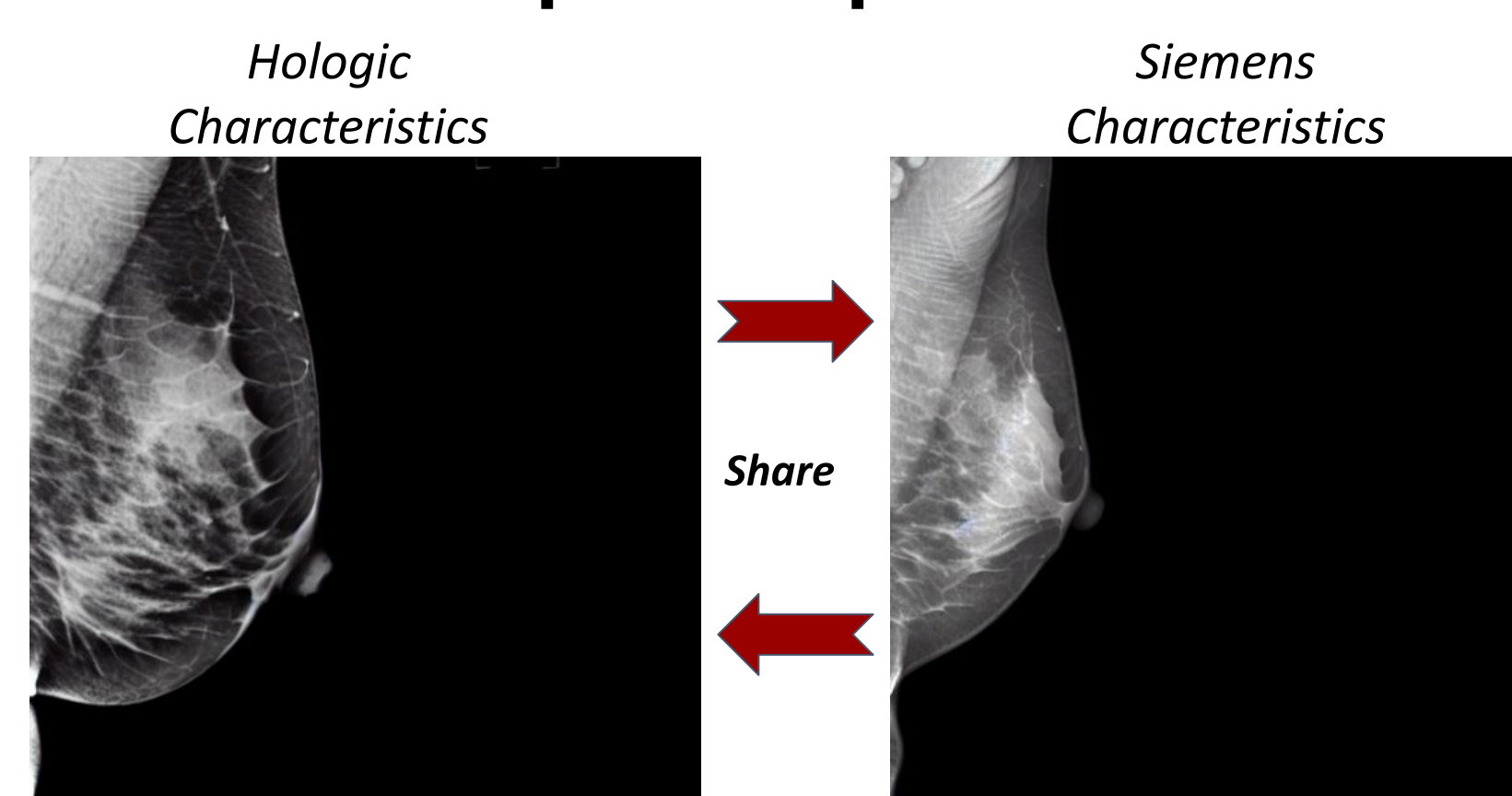


Training evolution



Prompt: "a siemens mammogram in MLO view with high density and small area"

Concept extrapolation



Conclusion

- Stable diffusion is a suitable generative model implementation to synthesize mammograms with control on specific image characteristics, and also for the inpainting of synthetic lesions.
- We can generate high quality synthetic mammograms whose visual characteristics can be considered real by a radiologist. Nevertheless, limitations like image resolution must be solved.
- We found first signs of CAD systems sensibility to our images, planning future PhD work on this.

Code



Weights

