Eindhoven MedTech Innovation Center

Paper

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Dehazing Ultrasound using Diffusion Models

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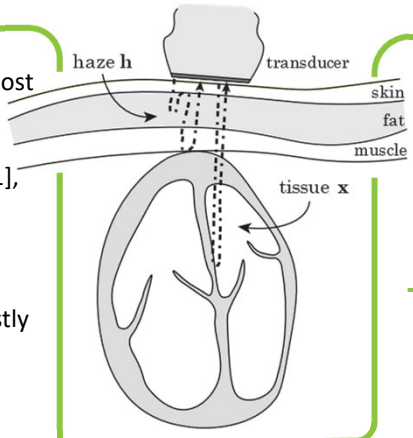
Domain: Cardiovascular **Keywords:** *Ultrasound, dehazing, cardiovascular, diffusion models, deep generative models*

Overview

- ✓ **Clinical challenge:** Echocardiography is one of the most important methods for diagnosing cardiac disease. However, image quality is heavily affected by haze [1], especially in technically difficult-to-image patients, such as those with obesity [2].
- ✓ **Goal:** Increase diagnostic confidence and reduce costly repeat examinations by removing haze.
- ✓ **Method:** Two diffusion models are trained to model both clean tissue and haze distributions [3]. These deep generative priors are then used in a Bayesian posterior sampling technique to dehaze ultrasound.



The good stuff

Diffusion models

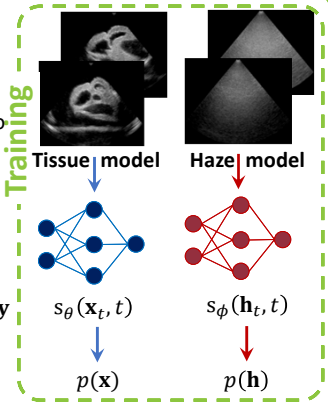
Train two diffusion models separately to model tissue and haze distributions.

Sampling

Hazy measurement $\mathbf{y}$

Clean signal $\mathbf{x}$

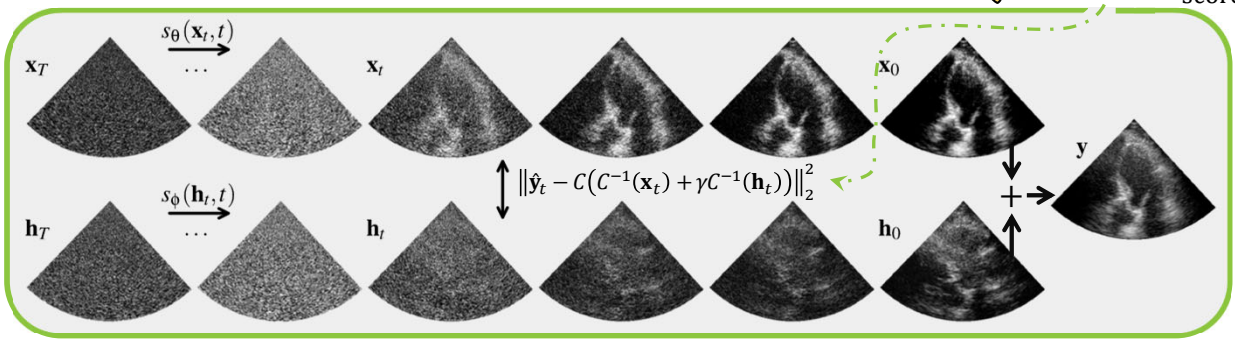
Extracted haze $\mathbf{h}$



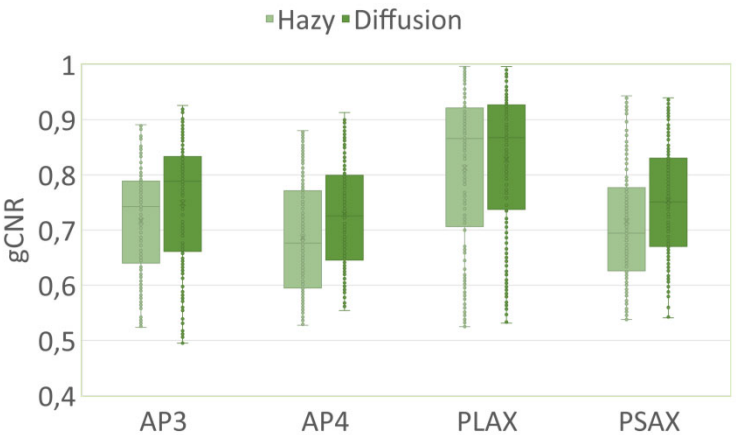
Bayesian Inference

$$\mathbf{x}, \mathbf{h} \sim \underbrace{p(\mathbf{x}, \mathbf{h} \mid \mathbf{y})}_{\text{joint posterior}} \propto \underbrace{p(\mathbf{y} \mid \mathbf{x}, \mathbf{h})}_{\text{data consistency}} \cdot \underbrace{p(\mathbf{x}) \cdot p(\mathbf{h})}_{\text{priors}}$$

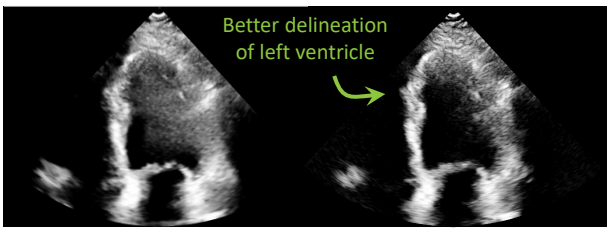
$\mathcal{N} \leftarrow p(\mathbf{x}_T)$ → noise sample → perturbed sample → data sample → $p(\mathbf{x}_0) \rightarrow \underbrace{\nabla_{\mathbf{x}_0} \log p(\mathbf{x}_0)}_{\text{score}} = s(\mathbf{x}_0)$



Results



In-vivo



Conclusion

Diffusion dehazing can effectively reduce reverberation artefacts in cardiac ultrasound while preserving detailed structures.

References: *[1] A. Fatemi, et al: "Studying the Origin of Reverberation Clutter in Echocardiography: In Vitro Experiments and In Vivo Demonstrations", 2019. [2] R. N. Uppot, "Impact of Obesity on Radiology", 2007. [3] T. S. W. Stevens, et al: "Removing Structured Noise with Diffusion Models", 2023.*