# Suppressing Streak Artifacts Generated by the Interference of Imaging and Therapy Fields: Initial Findings Using a Hybrid U-Net and Diffusion Model

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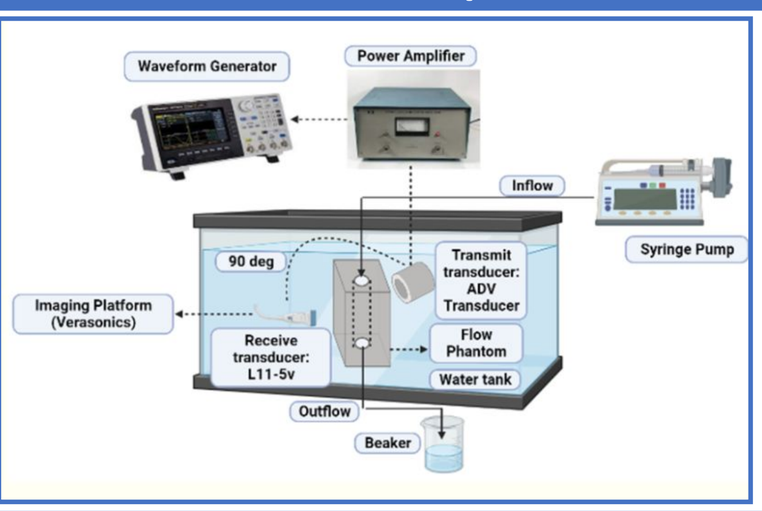
## Background and Motivation

- Therapeutic ultrasound applications include ablation, blood brain barrier opening, and drug delivery.
- B-mode ultrasound is used typically for image guidance and monitoring of therapy.
- When the therapy transducer is on, streak artifacts are produced in images because of interference between therapy and imaging fields.

## Methodology

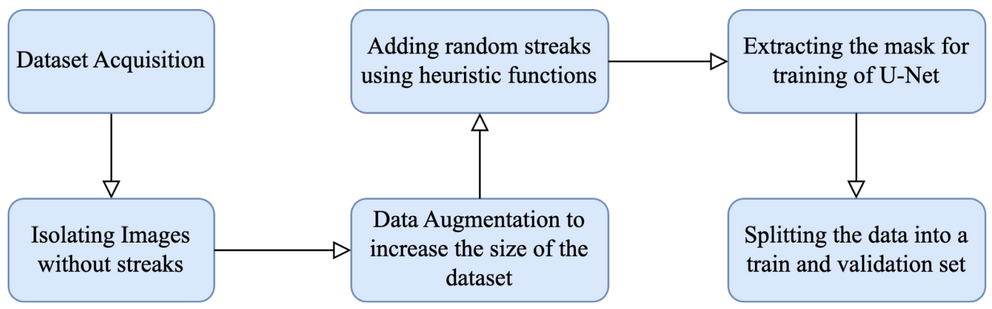
Data Acquisition from experiments → Synthetic Data Generation → Mask Generation from U-Net → Inpainting using Diffusion Model

## Experimental Setup



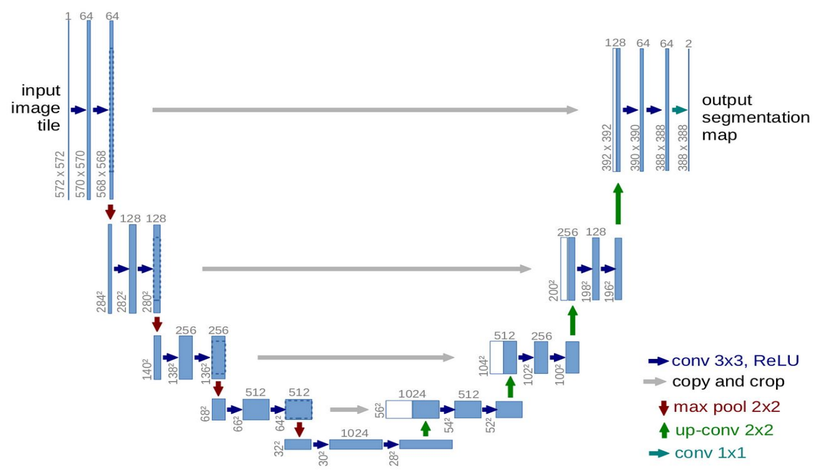

Insonating a wall-less polyvinyl alcohol phantom perfused with perfluorohexane droplets at 5 x $10^9$ droplets/ml undergoing phase transition.

## Generation of Synthetic Dataset




Model trained by artificially introducing streaks into 20 streak-free ultrasound images and obtained 1638 images.

## U-Net Architecture for Segmentation

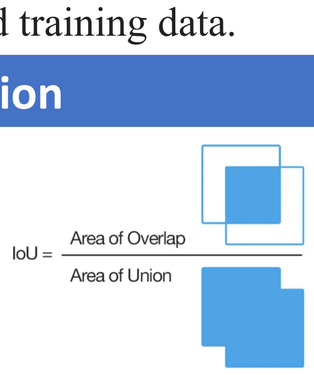



U-Net Architecture [1]

- The UNet is a neural network based on an Encoder-Decoder structure.
- The encoder (contracting path) extracts high-level features, while the decoder (expanding path) reconstructs segmentation maps.
- Suitable for biomedical images with limited training data.

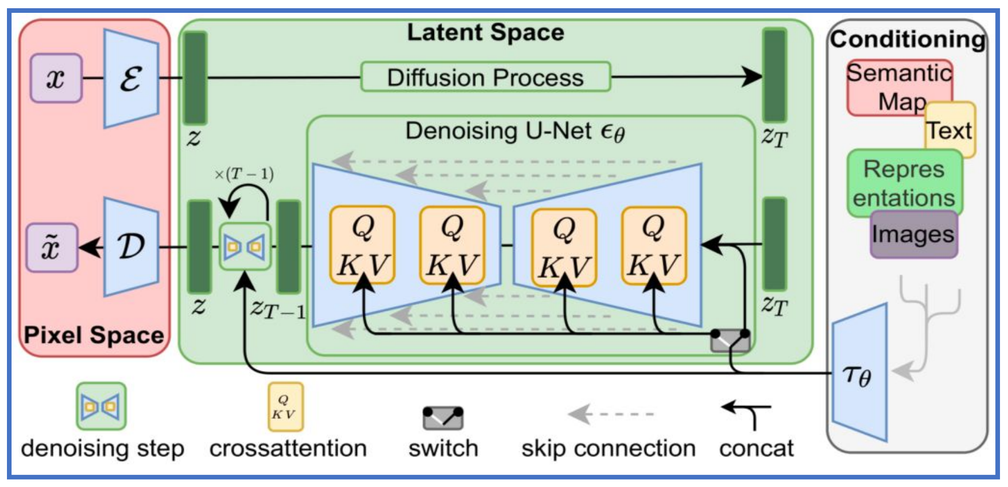
## Metric for Segmentation

IOU score (Intersection of Union), a metric quantifying overlap accuracy between predicted and actual segmentation




IOU Score [2]

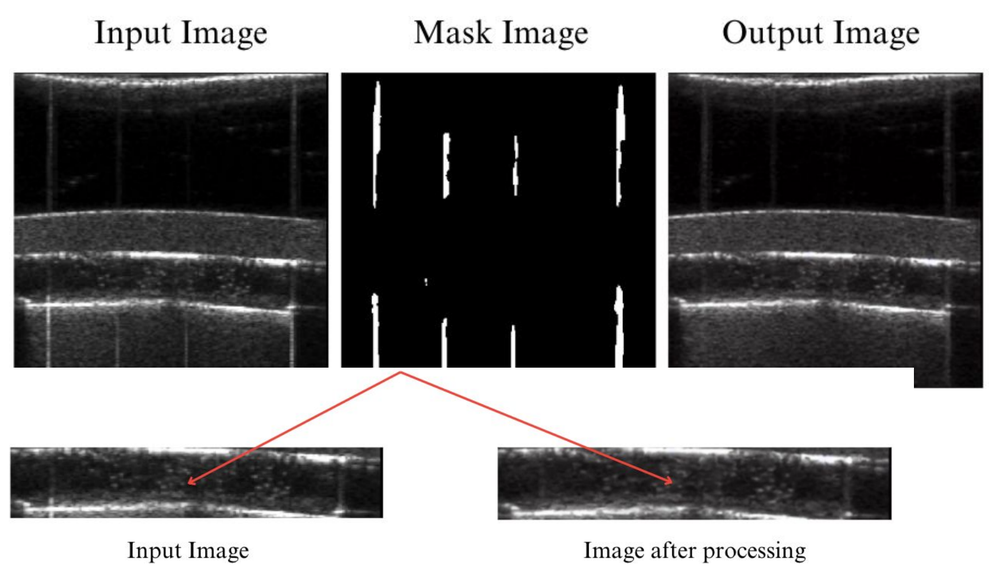
## Diffusion Models




Latent Diffusion Model Architecture [5]

- It is a denoising U-Net architecture
- The model takes three inputs: a noisy image, a mask and a conditioning signal (mostly text).
- It processes a latent space and a text-based prompt as inputs, denoising the image via a diffusion process.
- The conditioning signal provides additional information to guide the denoising process.
- Skip connections in U-Net link encoder and decoder layers, preserve fine details in the image during the denoising process.
- We used text prompts like “blend” to achieve the best inpainting results when a mask was given.

## Results




- Our results demonstrate the ability of our model to remove streak artifacts while preserving contrast from microbubbles.
- We see an increase in the Signal-to-Noise ratio by 6.0 ± 3.4 dB (n=154 frames)
- The model's rapid convergence underscores its potential for real-time clinical application.
- We reported an IOU score of 0.698.

## Summary and Future Work

- We integrated U-Net with diffusion models which provides a potential solution for streak artifact removal in therapeutic ultrasound imaging.
- Future work will focus on validating the model with more extensive and diverse datasets and reducing inference times.

## References

1. Source: Ronneberger et al., U-net, MICCAI 2015
2. Source: https://medium.com/@ankuraga/iou-score-and-its-variants-for-deep-learning-bd09ecf14832
3. Ronneberger et al., U-net, MICCAI 2015
4. Rombach et al., Latent Diffusion, CVPR 2022
5. Source: Ulhaq, Anwaar & Akhtar, Naveed & Pogrebna, Ganna. (2022). Efficient Diffusion Models for Vision: A Survey. 10.48550/arXiv.2210.09292.