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Abstract Title: Advancing Ultrasound Imaging through the Integration of Machine Learning and Wave Physics

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Introduction

Ultrasound Computed Tomography (USCT), also known as Full Waveform Inversion (FWI), is a medical imaging technique that reconstructs the mechanical properties of biological tissues by analyzing full ultrasound waveform propagation. USCT has significant potential in clinical imaging applications such as breast imaging, neuroimaging, and prostate tomography.

Objective

This work aims to develop hybrid USCT methodologies that combine physics-based modeling with machine learning to enhance image reconstruction accuracy while reducing computational cost.

Methods

We propose self-supervised learning frameworks integrated with ultrasound physics to reduce reliance on large labeled datasets and minimize computational overhead. In addition, we explore the use of diffusion models to constrain solutions to physically plausible domains, improving robustness and efficiency.

Results

The hybrid methods demonstrated effective reconstruction performance in complex brain and prostate imaging scenarios. Our approach preserves the quantitative accuracy of physics-based methods while significantly improving computational efficiency, particularly in ill-posed and non-convex optimization problems.

Significance

These advances represent a step toward clinically viable USCT systems. By combining the strengths of physics-based and machine learning methods, the proposed frameworks enable accurate, efficient, and scalable imaging solutions suitable for diverse clinical applications.

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References

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