2D ROC Analysis for Passive Cavitation Imaging of Ultrasound-mediated Histotrypsy

Bissem Gill [1]; Kevin Haworth[1]
[1]University of Cincinnati College of Medicine, Department of Internal Medicine, Cincinnati, Ohio

Introduction: Ultrasound-mediated cavitation is an acoustic technique that has been explored for various therapeutic applications, including thrombolysis, tissue ablation, and drug delivery. It involves using pulsed ultrasound waves to induce the creation or oscillation of small bubbles in tissue. At higher ultrasound amplitudes, these bubbles can collapse and ablate tissue.

Passive cavitation imaging (PCI) is a technique used to detect cavitation in the human body, making it potentially useful for guiding ultrasound therapies. Unlike other imaging techniques, it relies on a sensor that detects ultrasound signals emitted by cavitation without emitting a signal itself, ensuring minimal interference with the cavitation source in vivo.

Beamforming is a mathematical process that facilities the use of multiple imaging transducers in passive cavitation imaging. Improvements to the algorithm used to beamform image data can have a powerful impact on the resolution and signal to noise ratio of PCI data.

The Haworth lab has previously published an algorithm that applies spatial filtering to beamforming data, specifically targeting the improvement of axial resolution within the dataset. However, the algorithm includes a "fudge factor" parameter that was optimized for the original dataset it was developed against. Its generalizability to other datasets remains uncertain.

The Bader lab at University of Chicago has applied ultrasound to thrombi phantoms, and measured the resulting lesions using passive cavitation imaging. By aligning these lesions with the PCI data in MATLAB, the capability of passive cavitation imaging to localize these lesions can be examined. This imaging data was beamformed by the Haworth lab.

Methods: A script was written in MATLAB to align the beamformed passive cavitation imaging data with histology samples of the lesions generated by the Bader lab. To assess the effectiveness of the imaging data in predicting lesion locations within the phantoms, an ROC analysis and a Sorensen-Dice Coefficient will be performed as quantitative measures.

This analysis will be performed again over a second dataset made available by the University of Michigan. This dataset involves cavitation that was created by a different experimental configuration. Examining these two datasets will provide a powerful understanding of the ability for PCI data to predict lesion location, across two different cavitation imaging regimes.

In order to provide improvements to how the Haworth lab beamforming algorithm alters the ability for PCI data to predict lesion location, an ROC curve analysis will be performed to identify the optimal "fudge factor" parameter for this algorithm.

By systematically addressing these aspects, the project aims to enhance our understanding of the performance and potential improvements in PCI and beamforming. This project will characterize and optimize PCI localization of cavitation-mediated lesions in histotrypsy phantoms.

Results: <pending>

Conclusion: This work will elucidate the ability of beamformed passive cavitation imaging to localize lesions created by ultrasound therapy, and what the optimal fudge factor parameter is for the beamforming algorithm that is involved.

Acknowledgements: This study was supported in part by NIH grant T35 DK060444.