Visualizing vasculature in ultrasound guided therapy using C++ based open-source tools

Members: Andy Xia, Ziqi Zhao
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Introduction

Lab of Acoustic Therapy and Imaging (LATI) is focusing on various ultrasound guided therapies which includes ultrasound blood flow imaging to guide HIFU(high-intensity focused ultrasound) ablation, focused ultrasound neuromodulation and blood-brain-barrier opening(BBBO). One of the fundamental challenges in ultrasonic blood flow imaging is to suppress clutter signals originating from stationary and slow moving tissue, resulting in high-speed microbubbles (ultrasound contrast agents) signals that helped visualize the blood flow. In order to visualize the microvasculature during ultrasound guided therapy, an online filter is desired for this task. A butterworth high pass filter would simply do the job, but singular-value-decomposition(SVD) filtering can produce more promising results. Traditionally in LATI, we used a MATLAB script to filter and visualize during *in vivo* study. In this project, we want to achieve similar functionality through VTK and ITK and compare the results.

Source of data:

- Data from IEEE IUS conference super resolution imaging short course. This set of data is from a high frame rate rat brain imaging and had been beamformed(reconstructed).
- We want to acquire and beamformed a set of *in vitro* data using a cellulose-tube phantom embedded in agar-graphite gel to mimic the tissue environment.
- If an *in vivo* rat BBBO study happened before the presentation date, we will also attempt to process that data.

Approaches and Milestones:

1. Use Matlab, Slicer3D Filtering, and VTK frequency filters to process the data to see if the background tissue signal can be filtered out.
2. Following the Matlab script of SVD filtering, we want to implement a SVD filter utilizing ITK/VTK and C++. Compare the result with the Butterworth filter. We want to ensure high processing speed for good online capabilities.
3. （Advanced task) Use ITK with proper thresholding to attempt to localize individual microbubbles and show the possibilities towards sketching out vasculature.

Timeline and work division

Andy:

- Studying the math and MATLAB algorithm of SVD Filtering (Early November)
- Search for useful tools in VTK and ITK and design a working pipeline (Mid November)
- Acquire and Beamform phantom data (Late November)

Ziqi:

- Studying the math and MATLAB algorithm of SVD Filtering (Early November)
- Implement SVD algorithm and infrusture code via C++ (Mid to late November)

Together:

- Validation and test/debug (Late November ~ Early December)