Probe hardware and software updates

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1 Introduction

A spectral domain optical coherence tomography probe (hereafter "the probe") was designed by Nathan Lin, and is presented in his PhD thesis. While his preliminary work validated the functionality of this probe, a significant amount of work has been done since his departure to improve the probe's functionality.

In particular, I have worked at improving the probe's accessibility, allowing for better interfacing with the ThorImage software, and for real-time B-Scanning at higher quality than what ThorImage produces. I have also produced acquisition software that allows us to process probe-acquired data using the exact same pipeline as standard bulk-optics-acquired data.

In this document, I will discuss these advancements at a high level, giving significant detail for new features and leaving older features to previous documentation found on my GitHub page. In particular, for information on the probe, see the Probe Driver Report. For excruciating detail on the theory of OCT background subtraction and the acquisition/processing functions for the probe, see the Fixed-Background Processing Report.

I will first give a bit of intuition regarding the background used in OCT processing (Sec. 2), specifically as it pertains to use of the ThorImage software. I avoid repetition from my previous report and look only emphasize and explain some phenomena we have recently observed using the probe alongside ThorImage.

I will continue with an overview of the circuit's functionality (Sec. 3). I emphasize key changes since the last report was written, and signal qualities that need to be kept in mind when changing between probes.

I will then discuss updates to the control programs used for acquiring and observing data from the probe (Sec. 4). I will also discuss the means by which ThorImage can be used with the probe, and how the data displayed in ThorImage ought to be interpreted (Sec. 5).

Finally, I will show some important data taken from the probe which ought to influence how we interpret all future probe-acquired scans. First, we show that the SNR in water is significantly worse than that in air (Sec. 6.1), which is important for *in vivo* experiments where data is taken in the fluid of the cochlea. Lastly, we show an interesting phenomenon wherein despite low SNR, we can achieve informative B-Scans formed of low-quality A-Scans (Sec. 6.2). We discuss how this fact can be used to extract location information from the time-averaged M-Scan magnitude.

2 The background in OCT processing

2.1 Why do we need a background?

2.2 How does ThorImage capture the background?

2.3 How do our programs handle the background?

3 Probe control signals and circuitry

3.1 Telesto output signal

3.2 Circuit function and capacitance values

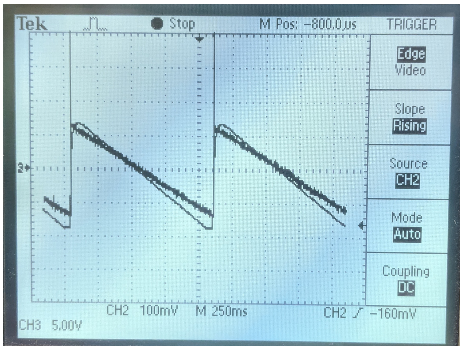

Figure 1: Response at 10 kHz.

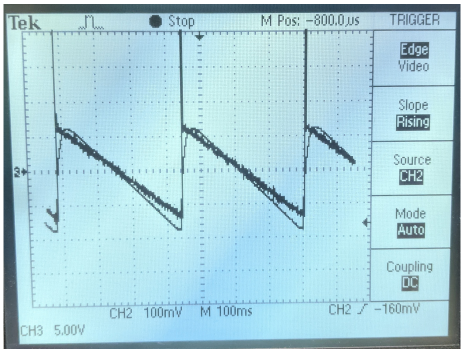

Figure 2: Response at 28 kHz.

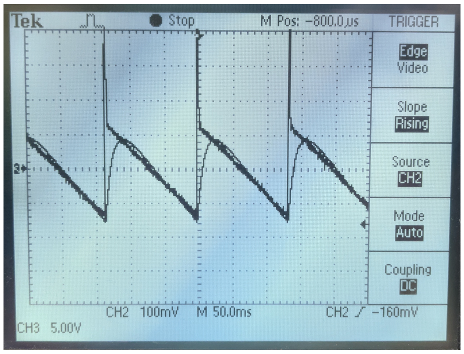

Figure 3: Response at 76 kHz.

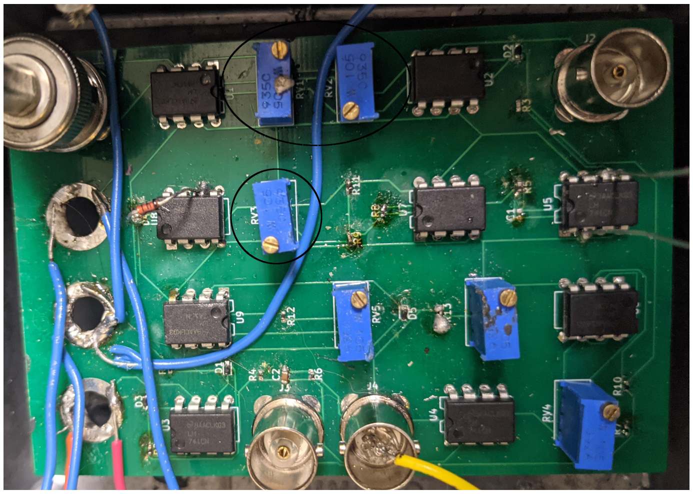

Figure 4: Response at 76 kHz.

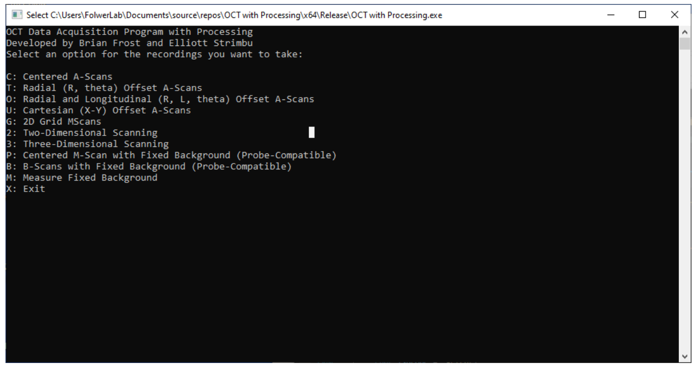

Figure 5: .

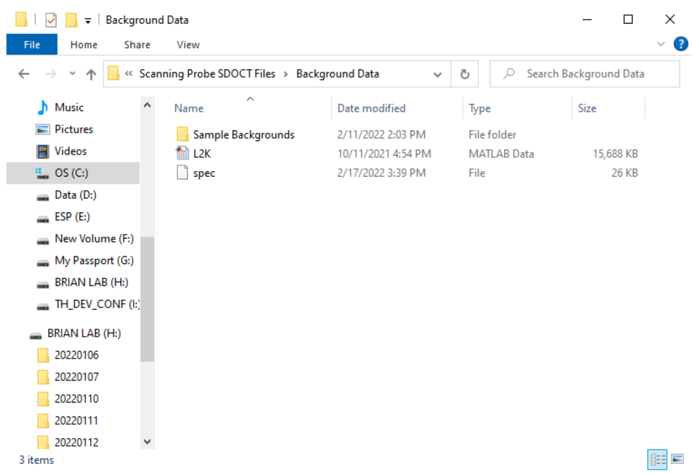

Figure 6: .

3.3 Adjusting resistances for each probe

4 Control programs for fixed background

4.1 Option M: Measure Background

4.2 Taking and observing B-Scans with fixed background

4.3 Option P: M-Scans with fixed background

5 Using ThorImage with the probe

5.1 The ThorImage “fake background” trick

6 Signal quality

6.1 SNR in air vs. water

6.2 B-Scan quality

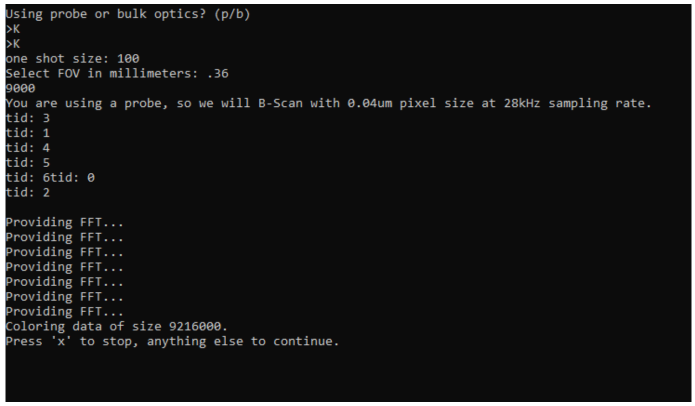

Figure 7: .

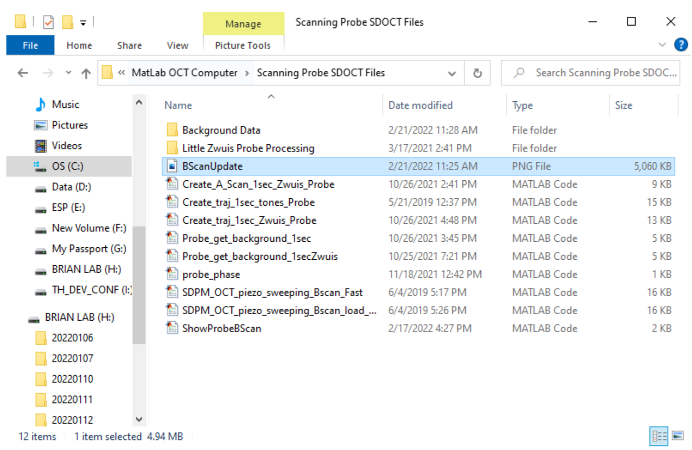

Figure 8: .

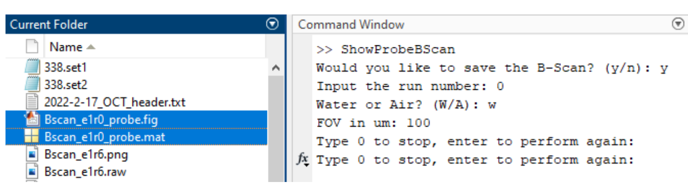

Figure 9: .

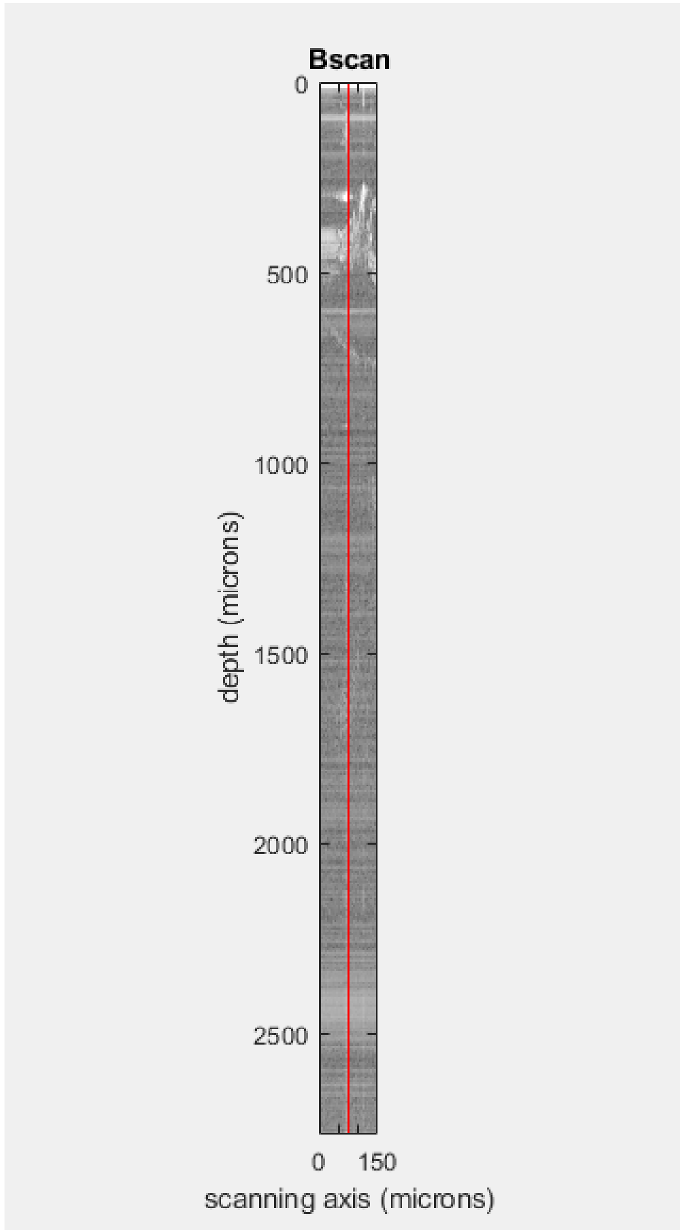
Bscan
0
500
1000
1500
2000
2500
depth (microns)
0
150
scanning axis (microns)

Figure 10: .

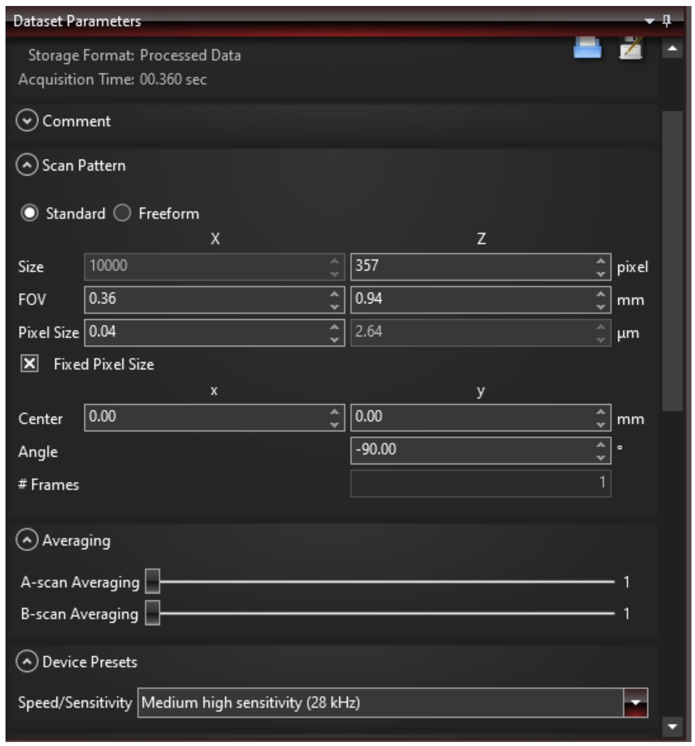
Dataset Parameters
Storage Format: Processed Data
Acquisition Time: 00.360 sec
Comment
Scan Pattern
Standard
Freeform
X
Z
Size
10000
357
pixel
FOV
0.36
0.94
mm
Pixel Size
0.04
2.64
µm
Fixed Pixel Size
x
y
Center
0.00
0.00
mm
Angle
-90.00
°
Frames
1
Averaging
A-scan Averaging
1
B-scan Averaging
1
Device Presets
Speed/Sensitivity
Medium high sensitivity (28 kHz)

Figure 11: .

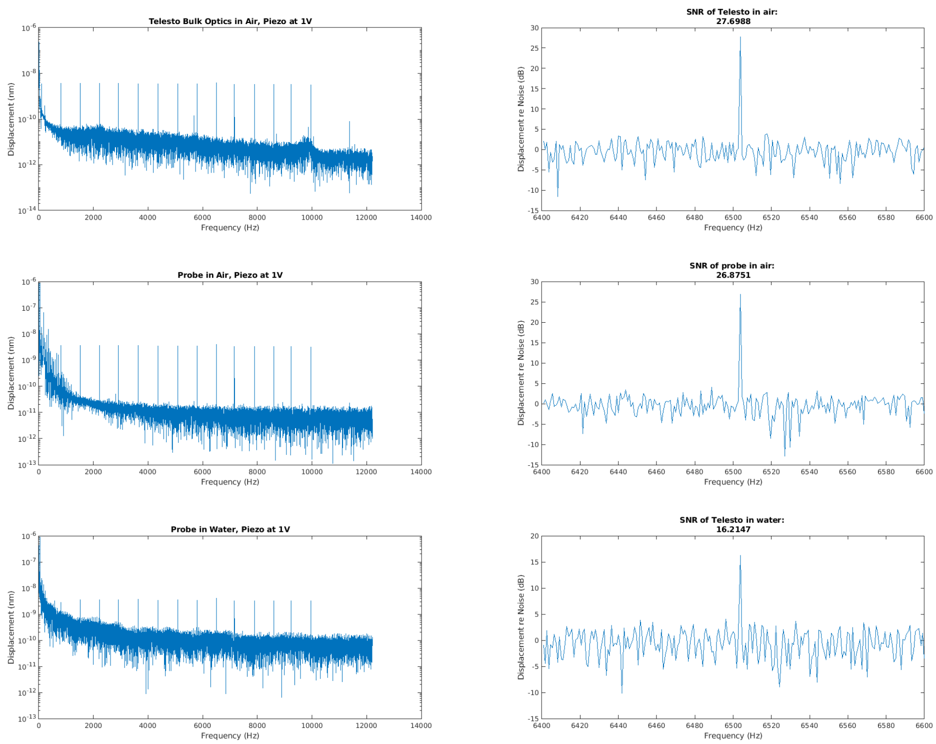
Telesto Bulk Optics in Air, Piezo at 1V
SNR of Telesto in air:
27.6988
Probe in Air, Piezo at 1V
SNR of probe in air:
26.8751
Probe in Water, Piezo at 1V
SNR of Telesto in water:
16.2147
Displacement (nm)
Frequency (Hz)
Displacement re Noise (dB)

Figure 12: .

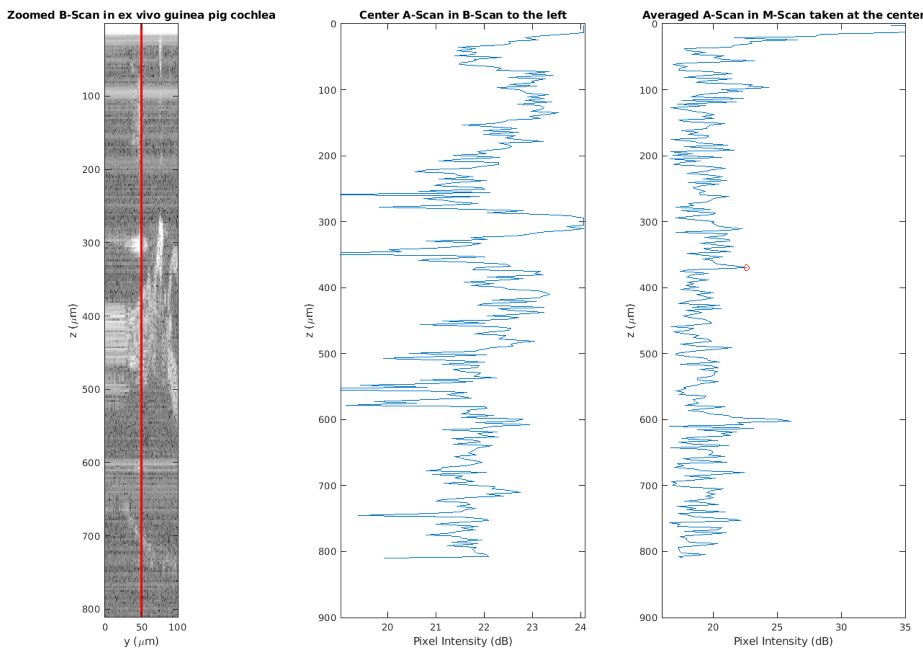
Zoomed B-Scan in ex vivo guinea pig cochlea
Center A-Scan in B-Scan to the left
Averaged A-Scan in M-Scan taken at the center
z (μm)
y (μm)
Pixel Intensity (dB)
Pixel Intensity (dB)

Figure 13: .