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# Utility of Ultrasound/Photoacoustic Imaging for Accurate Catheter Tracking and Temperature Monitoring During Endovenous Laser Ablation

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## Introduction

## Results and Discussions

### Ultrasound and Photoacoustic for Catheter Localization

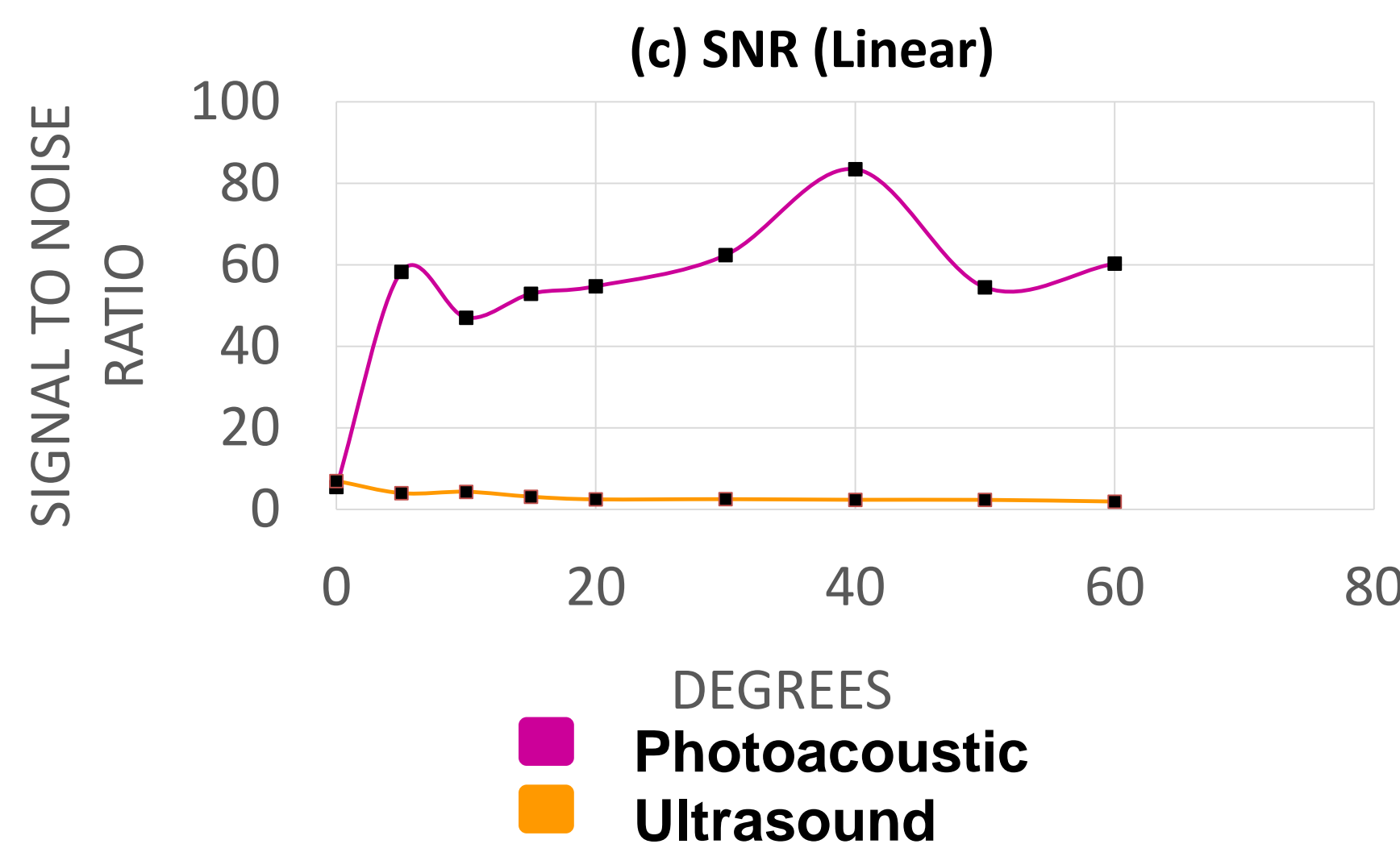
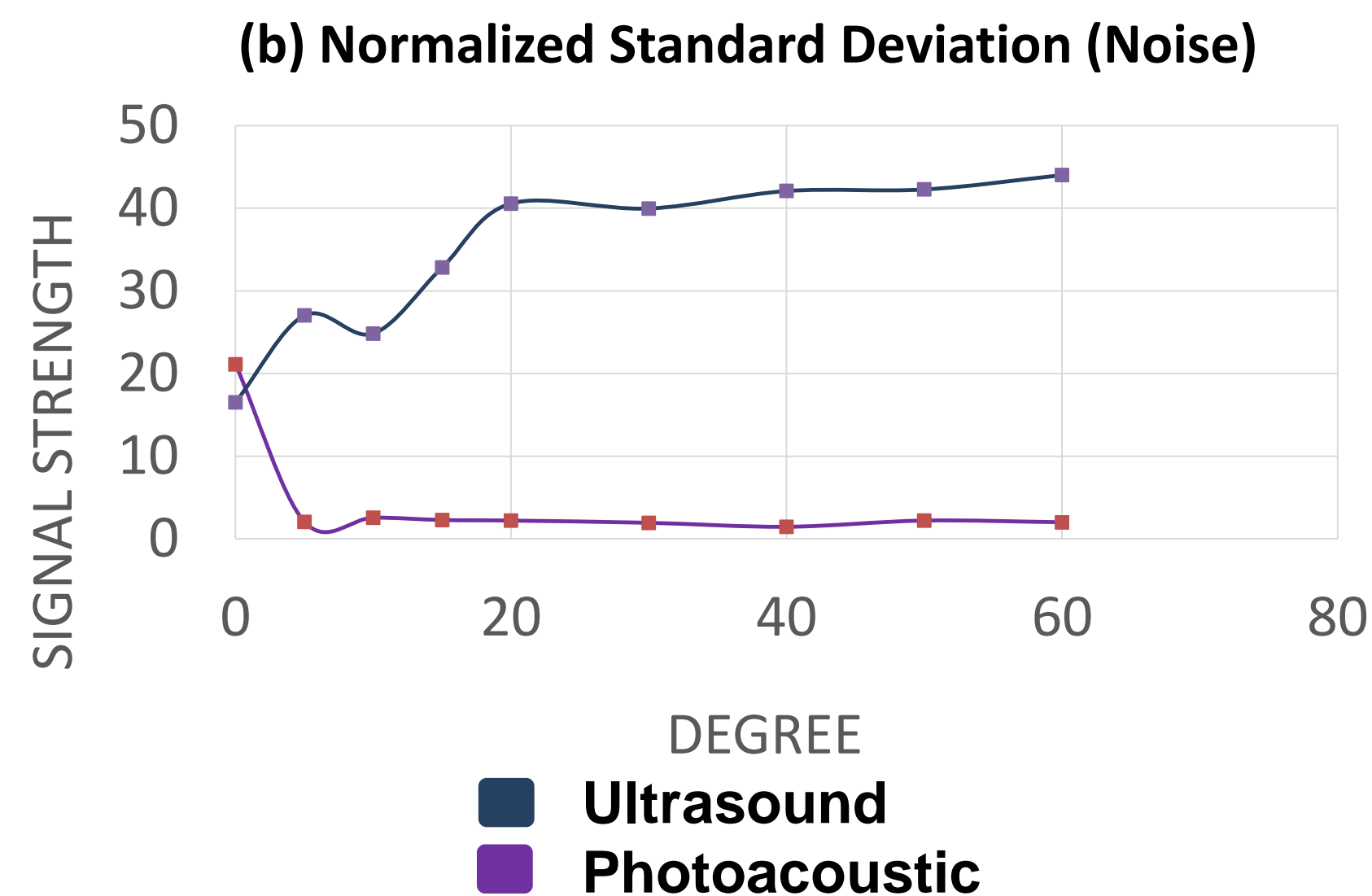
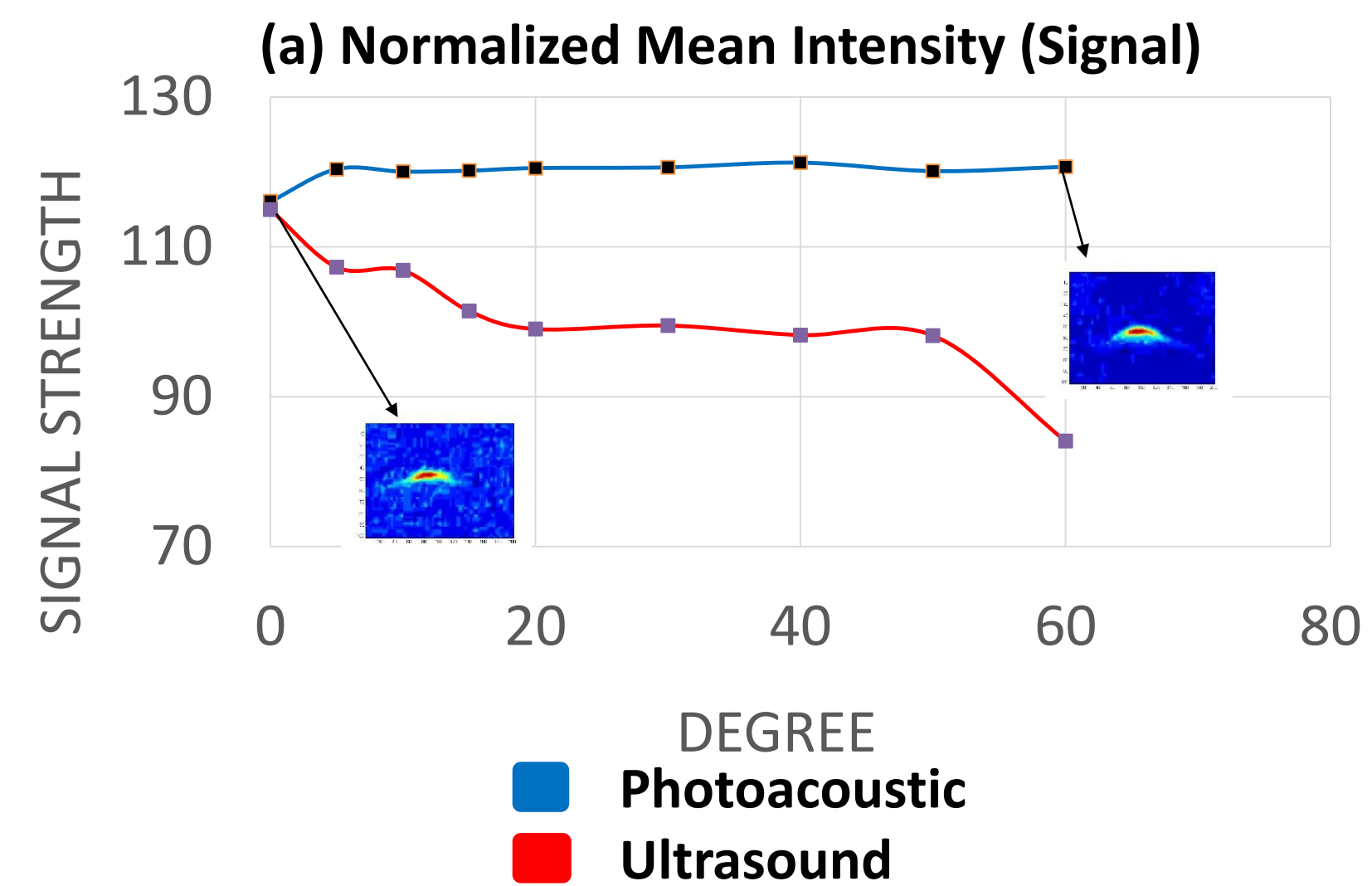


Figure 3:(a) Normalized mean, (b) Normalized standard deviation (noise), and (c) SNR comparison between US and PA imaging for localizing fiber optic with angular variation of 0 to 60 degrees.

- Quantitative comparative analysis between US and PA methods indicate that the photoacoustic has superior abilities for laser ablation catheter localization and tracking.
- Photoacoustic images of fiber optic are shown to be independent from the angle of the fiber with respect to US transducer.

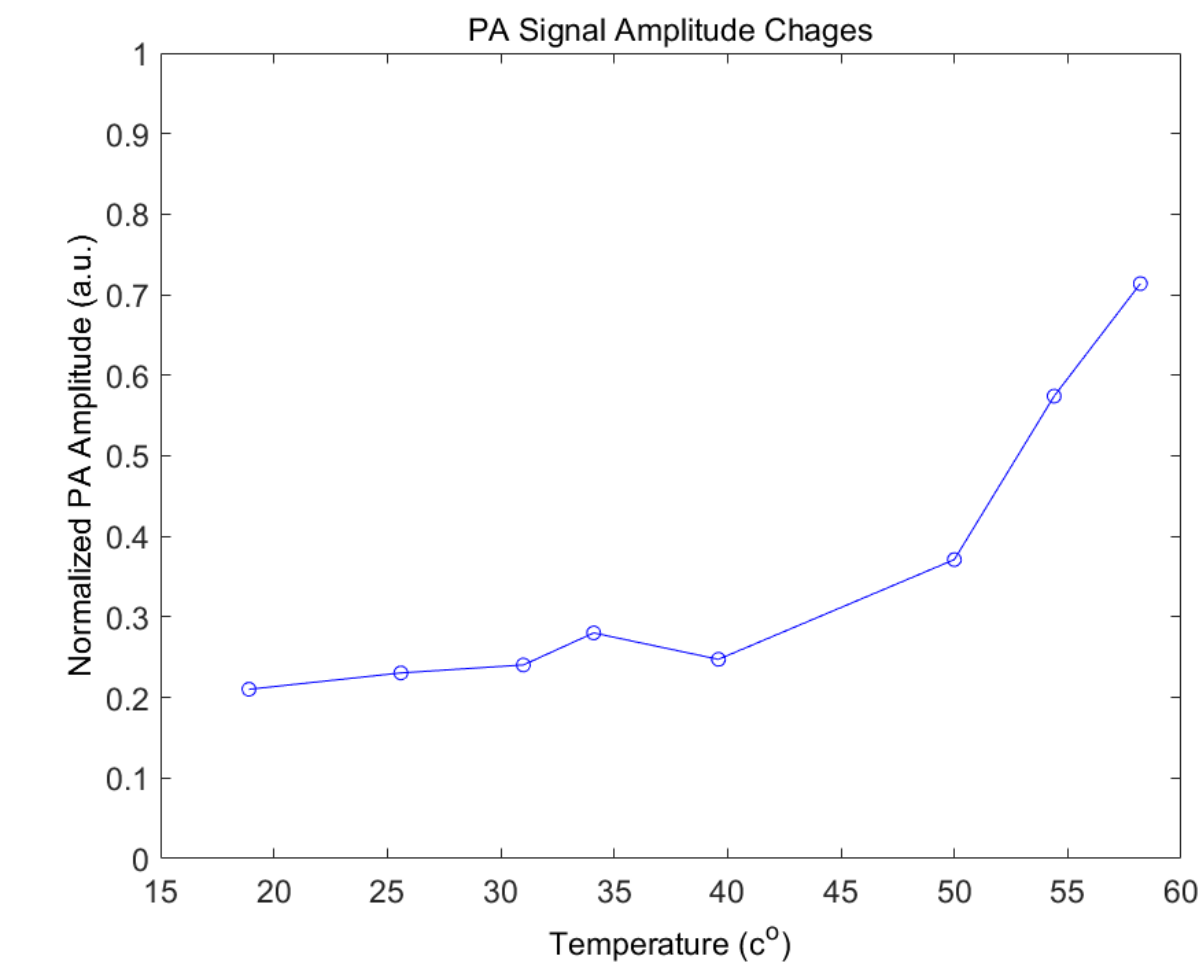


Figure 4: Photoacoustic signal amplitude increment by increasing ambient temperature.

- PA signal amplitude increases by temperature indicating the possibility of utilizing PA imaging for real-time monitoring the temperature during endovenous laser ablation.

## Conclusion

- Combined US and PA imaging can provide a suitable platform for visualizing tissue structure and the location of the ablation catheter.
- Robust and highly localized temperature monitoring by PA is a promising tool for more accurate management of therapy procedures.
- Our results show that PA , provides more accurate platform for tracking laser ablation catheter
  - Angular independent
  - Speckle-free
  - No comet-tail artifact
- Since laser ablation catheter includes fiber optic, the choice of PA for tracking the fiber does not require major change in existing ablation catheters.

## References

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- Laser ablation is a treatment method that uses light energy through a catheter inserted into a vein to induce localized heat to close the diseased blood vessels.
- Ultrasound (US) imaging has been used for catheter visualization and tracking. US has limitations for tracking the accurate location of the fiber tip inside small perforating veins such as angular dependency and comet tail artifacts.
- We propose a robust and accurate method for fiber tip tracking using combined US and Photoacoustic (PA) imaging to overcome the existing limitations.

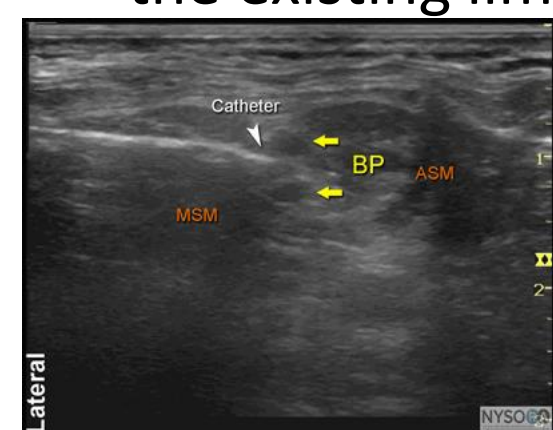


Figure 1: Image of ultrasound-guided catheter insertion between anterior (ASM) and middle (MSM) scalene muscles. BP stands for the anatomical structure brachial plexus. (Adopted from NYSORA)

## Methods & Experimental Set Up

### Experimental Setup:

- PA experiments were performed with a pulsed laser (SpectraPhysics-PRO290) laser energy at 3.760 mJ/pulse.
- A linear array ATL L7-4 US transducer was utilized for acoustic signal acquisition.
- The optical fiber (multimode,1000 μm core) was used to transfer the laser energy into the system and a custom-designed mechanical arm was used to tilt the fiber at 0, 5, 10, 15, 20, 30, 40, 50, and 60 degrees.
- Imaging medium was sterilized, heparinized sheep blood.

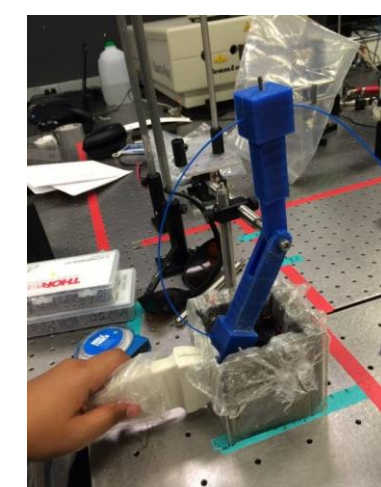
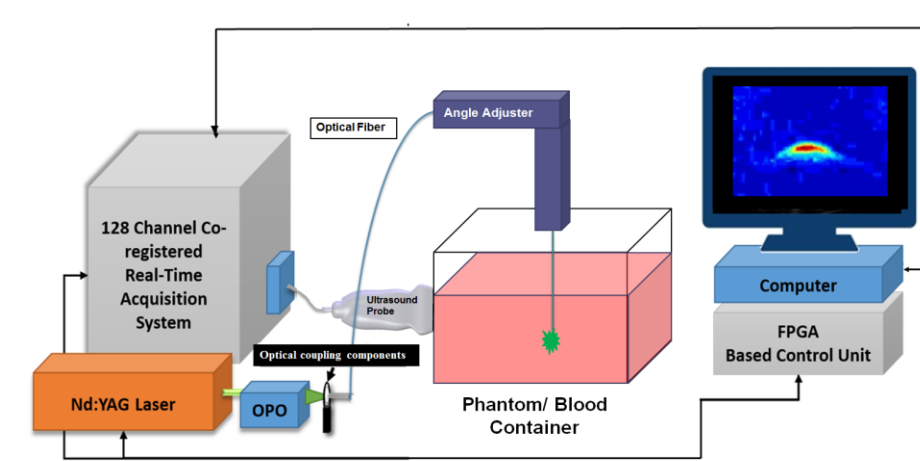


Figure 2: (Left) Diagram of experimental setup for fiber tracking. (Right) Photograph of the setup

### Data collection:

- A programmable digital US research platform (Verasonics, Vantage128) was used to record PA and US data.
- Data processing include selecting the ROI of each US and PA image, calculating the signal strength and the background noise.