Photoacoustic Guided Ultrasound Wavefront Shaping For Targeted Acousto-Optics

Jacob Staley, Erwin Hondebrink, Wilma Petersen, Wiendelt Steenbergen
Biomedical Photonic Imaging Group, MIRA Institute for Biomedical Technology and Technical Medicine, University of Twente, Enschede, The Netherlands

Background

Why it’s needed

• Ultrasound focus induces phase shifts in light that passes through the focus (“tagging volume”)
• Speckle pattern is detected by CCD camera
• Speckle contrast reduction gives information about “tagged” light

• Acousto-optic (AO) signal is highly dependent on formation of ultrasound focus
• Loss of acoustic focus results in loss of localized optical information
• Possible to compensate for speed-of-sound aberrations by using photoacoustic (PA) signal to guide ultrasound wavefronts using cross-correlation techniques?

• Aberration of PA wavefronts due to speed-of-sound variations

Commercial Ultrasound System

• Ultrasound generated by portable, commercially available system – MyLab™ One, Esaote
• 128-element linear phased array (64 active elements per transmission/receive). Center frequency of 7.5 MHz (model SL3323)

Ultrasound Focus Comparison

• Needle hydrophone measurement of unguided and photoacoustic guided focus

AO+PA Setup

• Stroboscopic parallel speckle detection via CCD camera
• 532 nm coherent light used for AO
• 532 nm plus optional NIR used for PA
• Phase screen (PS) aberrates acoustic waves
• Ultrasound array (UA) targets contrast agent (CA) for AO measurement

Gold Nanoparticles

• Sodium alginate beads composed of gold particles are used as PA source and AO target
• Bead diameters range from 1-4 mm
• Ability to selectively target PA source by varying optical wavelength
• Choose what contrast agent guides ultrasound focus for AO measurement

Results

• Targeting 2mm bead containing GNS
• AO measurement for both ultrasound focusing techniques
• With and without aberration

Conclusions

• PA guidance of ultrasound serves as a robust method for correcting SOS aberrations
• Possible to perform targeted AO imaging
• Ability to selectively choose AO target by matching absorption spectrum with PA optical excitation wavelength

Acknowledgements

• Research supported by STW under vici-grant 10831, and by the MIRA Institute of the University of Twente.