Visualization of diagnostic ultrasound field using LED and smartphone camera

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Background, Motivation and Objective

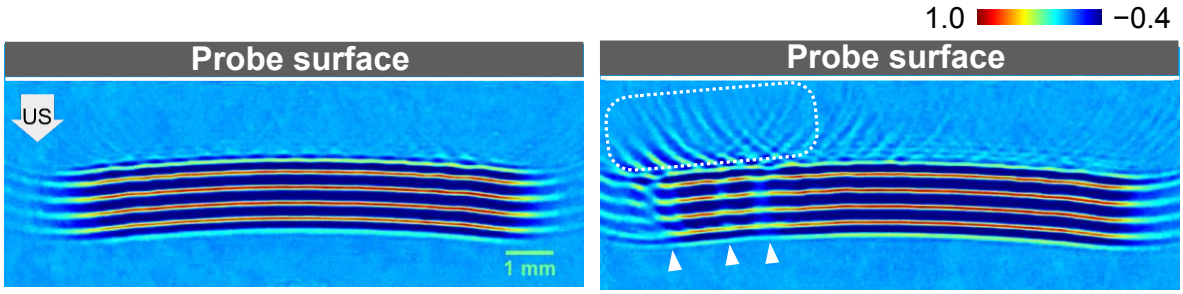
We have been studying an optical technique for ultrasound field visualization, i.e., focused shadowgraphy. In previous studies, a system was developed to confirm the ability of the technique for visualization of diagnostic and therapeutic pressure fields. Different from Schlieren, the technique can be performed using non-coherent optics with a light source and a camera. In this study, a simple system using an LED and a smartphone camera was tested to show the practical usefulness of the technique.

Statement of Contribution/Methods

A high-brightness LED of λ=610 nm (OS6OGA5111A, OptoSupply, China) with a collimator lens (#62-760, Edmond Optics, USA) was used for an illuminating light source. The LED was driven by a 50-ampere laser diode driver (PCO-7114-50-4, IXYS, USA) to make 30-ns light pulses for stroboscopic observation of a propagating ultrasound pulse. The built-in camera of a smartphone (iPhone 7 plus, Apple, USA) with a macro lens (AP-008, APLUS, Japan) was used at the setting of 70 mm in focal distance and 300 ms in exposure time. A diagnostic ultrasound scanner was set to a pulse Doppler mode, and ultrasound pulses of 5.3 MHz in center frequency were generated using two linear probes.

Results/Discussion

Figure 1 shows shadowgrams of the ultrasound pulses propagating downward at a distance of about 2 mm from the ultrasound irradiating surfaces of the probes: (a) a probe with no element failure and (b) a probe with several elements of decreased sensitivity. The shadowgram of the normal probe shows that a burst ultrasound pulse of 6 cycles in duration and about 10 mm in width was generated with a concave wavefront converging on its focus. The shadowgram of the damaged probe shows local decreases in brightness (closed arrowheads) down to ~70% and irregularity in the wavefront. Furthermore, tailing of the pulse wave was clearly increased in the area including the damaged elements (open rectangle), indicating that degraded beamforming increases the pulse duration that results in a decreased spatial resolution. This result shows that the focused shadowgraphy system constructed using daily-use devices has a potential for sensitive detection of diagnostic ultrasound fields. This study was partially supported by JSPS KAKENHI 17H00864.



(a) Normal probe (b) Damaged probe

Figure 1. Shadowgrams of ultrasound pulses propagating near the surfaces of two linear probes without and with element failure. The images were normalized and displayed using pseudo color.