High-resolution optical imaging deep inside scattering medium with spatial gating by focused ultrasound

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When a scattering layer is introduced between an imaging object and an objective lens, the conjugate relation between object plane and detector plane is impaired. Consequently, signals originating from locations other than the conjugate position contributes to the specific detector element and degrade signal to noise ratio. To attenuate this noise, we propose here to use a focused ultrasound beam for spatially gating those optical waves transmitted through an imaging area. The optical signal is modulated through an acousto-optic effect, and only the frequency-modulated component is selectively detected at the sensor plane using an interferometric method. We further suppress the effect of noise with a synthetic aperture method that coherently accumulates the image-bearing (ballistic) component. Using this new imaging method combining the space-gating and synthetic aperture method, we demonstrated the imaging of absorptive objects buried inside a highly scattering medium up to the depth of $l = 1 \sim 15\ l_s$, where l and l_s are the thickness of the scattering medium and its scattering mean free path.