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Hybrid Optoacoustic and Ultrasound Imaging System with a Multi-Segment Detector Array

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The high complementarity of the optoacoustic (OA) and pulse-echo ultrasound (US) modalities makes the combined usage of these imaging technologies highly advantageous. Yet, due to the different physical contrast mechanisms, the development of detection technology optimally suited for image acquisition in both modalities remains a major challenge. Here we demonstrate a multi-segment detector array whose novel design is meant to optimally support both ultrasound and optoacoustic image acquisition.

(2) Material and Methods

For the OA signal excitation, light from the pulsed Nd:YAG-pumped OPO is guided to the specimen via a custom-made fiber bundle at 25 Hz repetition rate, with 25mJ per-pulse energy output. Switching between OA and US imaging modes is facilitated through a custom-made multiplexer (MUX) connected to the transducer array. The latter combines two detector geometries: the linear segment of 128 elements (0.25 mm pitch and 10 mm height), and two concave segments - each having 64 cylindrically-focused elements with 0.6 mm pitch, 10 mm height, and a focal distance of 38 mm. All elements have a central frequency of 7.5 MHz.

(4) Discussion and Conclusion

The hybrid-array-based imaging approach can greatly facilitate clinical translation of the OA imaging technology by means of its efficient combination with a well-established US imaging modality. Imaging sessions in a healthy volunteer have proven excellent capacity of the new OPUS approach for hybrid anatomical imaging and functional angiography in humans.

(3) Results

Characterization of the sensitivity field of the detector by means of numerical simulation allows for quantitative assessment of the effective field of view in both imaging modes, which in OA mode along x- and y-dimensions constitutes 30x25mm2, and 30x30mm2 in the US imaging mode. Estimated OA in-plane axial and lateral resolution is within the range 90-130µm and 110-180µm, respectively. The US in-plane resolution along axial and lateral dimensions was estimated between 210-260µm and 260-340µm, respectively. The capacity of the hybrid system for real time in vivo functional imaging of blood oxygenation using multi-wavelength data acquisition is demonstrated in healthy volunteer study for anatomical regions of wrist and neck.

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