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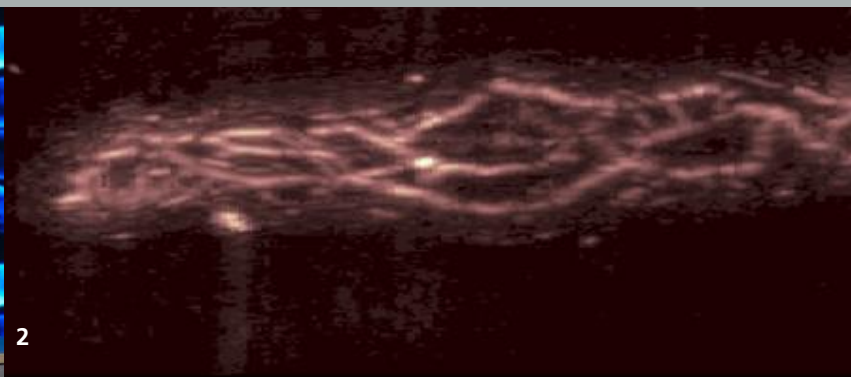


1 *combined optoacoustic/acoustic system for tomographic imaging of finger joints*
2 *3D reconstruction of optoacoustic signals acquired from human blood vessels*

Fraunhofer Institute for Biomedical Engineering IBMT
Prof. Dr. Heiko Zimmermann
Joseph-von-Fraunhofer-Weg 1
D-66280 Sulzbach
Germany

Contact

Dr. Marc Fournelle
Ultrasound Division
Telefon +49 6897 9071 310
marc.fournelle@ibmt.fraunhofer.de

www.ibmt.fraunhofer.de

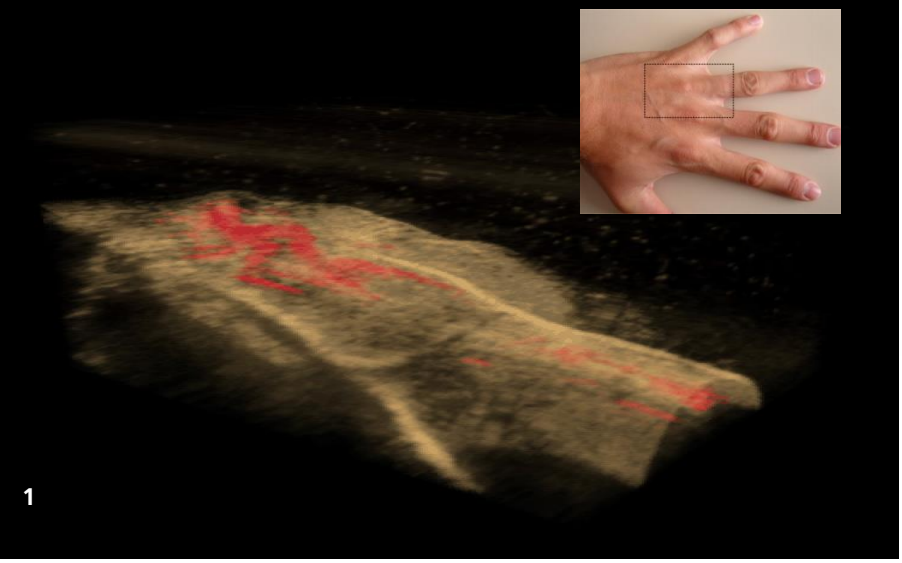
OPTOACOUSTIC IMAGING

Situation

Optoacoustic imaging is a new hybrid modality that combines the advantages of acoustics and optics. Ultrasonic signals are generated by the absorption of light. These signals can then be utilized for imaging in which the high contrast of optics and the high resolution of acoustics are combined. By adding appropriate nanoscaled and biologically functionalized contrast agents, optoacoustics can also be used for macroscopical molecular imaging. The achievements of the IBMT in the field of optoacoustics range from contrast agent syntheses to design and assembly of entire imaging systems.
Furthermore, this modality is optimally applicable for image vessel structures, even far beyond the resolution limits of Doppler ultrasound.

Solution

The IBMT has developed a hardware platform based on the DiPhAS (Digital Phased Array System, Fraunhofer IBMT), that allows ultrasonic imaging as well as optoacoustic imaging. The system allows both single mode imaging either (optoacoustic or ultrasound) or combined imaging. In the latter mode, the system triggers an external laser source. Different trigger settings are possible, so that all kind of pulsed lasers (Nd:YAG, OPO) can be used for optoacoustic imaging. The time between laser events is used for acquisition of ultrasound data in a plane wave compounding mode. Both US and OA data are transferred to a PC after amplification and digitization, where they are reconstructed on a GPU by means of time-domain beamforming algorithms. The main difference with respect to the hardware setup between OA and US compared to conventional ultrasound imaging is the



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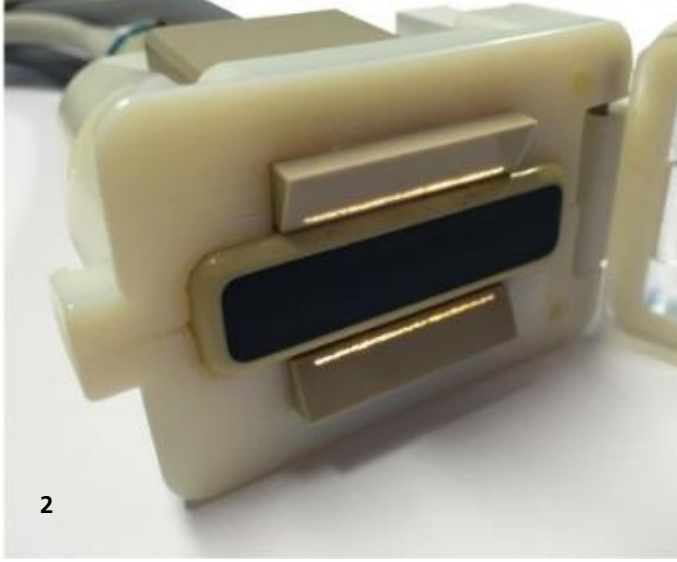

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need for an optimized delivery system. For this purpose, custom made fibre bundles and adapters for different transducer types were developed.

Technical Data

- Digitalization with 80 MSamples/s for transducers with a frequency of up to 20 MHz
- Channel data of up to 128 elements can be acquired
- Software-based reconstruction based on time domain beamforming in real time (GPU based)
- Different trigger outputs for different laser systems (Nd:YAG, OPO)
- Real-time optoacoustical imaging with up to 100 fps
- Combination with ultrasound imaging (plane wave compounding) in automated hybrid imaging mode (no need for manual switching)
- Fibre optics optimized for optoacoustic signal generation

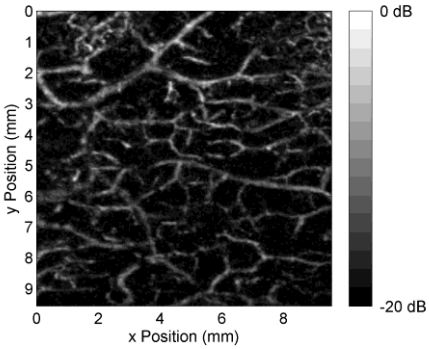
Imaging of Vascularization

Due to its high absorption coefficient blood can be imaged in optoacoustic mode with an extremely high contrast.
This method is especially suitable when a resolution beyond the limits of Doppler-ultrasound is required, or when there is only little blood flow or no blood flow at all.
Furthermore, optoacoustic technique allow functionalized imaging of vasculature. Given that signal amplitudes are directly proportional to the absorption coefficient, tissues can be identified when their optical spectral signature is known and optoacoustic signals are acquired with different wavelengths (using tuneable OPO systems). In this approach, spectral unmixing algorithms can be used to identify different tissues based on their spectral signature. For instance, oxy- and deoxyhemoglobin can be differentiated given that the oxygen saturation of blood has a direct impact on its absorption coefficient. Accordingly, oxygen saturation levels can be mapped with high spatial resolution. By utilization of a laser system with adjustable wavelength (OPO), multispectral optoacoustical data sets can be acquired.

Combined US/OA imaging system with clinical certification

High resolution imaging

In addition to multichannel imaging systems, IBMT has developed platforms based on focused single element transducers and single channel electronics for high resolution applications (dermatology, preclinical small animal imaging). Such systems allow spatial resolutions better than 100 µm with transducers in the 35 MHz range.



Optoacoustic C-scan of subcutaneous vasculature acquired with 35 MHz transducer

Clinical Use

IBMT´s optoacoustic imaging system has been tested according to the standards defined by the medical device directive MDD 93/42/EEC. In particular, the system is compliant with standards for electrical safety and electromagnetic compatibility, as well as acoustic and optic safety.

1 *3D reconstruction of optoacoustic data of subcutaneous blood vessels*

2 *128 element 5 MHz probe integrated with custom fibre bundle for optimized illumination*