MULTIMODAL IMAGING SYSTEM
FOR DIAGNOSIS & MONITORING
INFLAMMATORY & ARTHRITIC
DISEASES

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MEDICAL NEED FOR IACOBUS

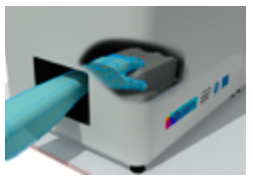
Arthritic diseases, including rheumatoid arthritis (RA), psoriatic arthritis (PSA) and osteoarthritis, have a prevalence between 1 and 3% and lead to joint destruction and deformation resulting in a loss of function. The joints of the fingers and hands are frequently affected, and progression of the arthritic disease severely affects the patients' quality of life.

Different studies on rheumatoid arthritis have shown that a therapeutic window of opportunity exists in the first year and particularly in the first 3 months after the onset of the disease, during which a treatment has a higher likelihood for improving the course of this devastating disease.

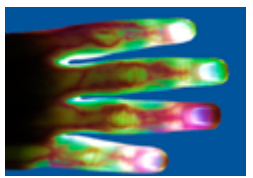
In order to achieve an adequate therapeutic response, not only an early detection of symptoms but also a precise classification of the disease is necessary. A frequent difficulty is the differentiation between osteoarthritis of the finger joints and RA or PSA in its early stages.

Currently available diagnostic imaging tools are poorly suited to detect early signs of arthritic inflammation. Available diagnostic modalities such as ultrasound, Doppler, MRI or X-ray are either not sensitive enough or not suitable for repeated screening examinations due to the use of ionizing radiation or high costs.

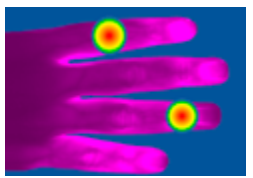
The hyperspectral imaging system.



Scanned patient hand on transmittance and reflectance modes using non-invasive light sources.



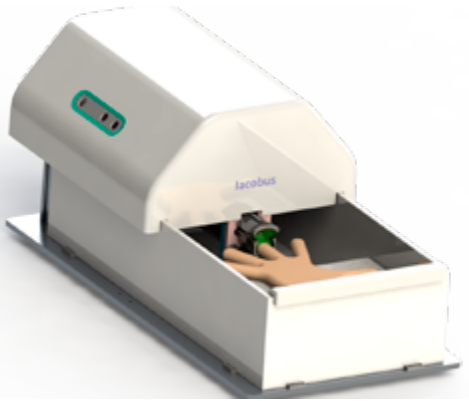
High resolution spectra of a hand, collected from the 600 nm - 1200 nm spectral region in each pixel of the image.



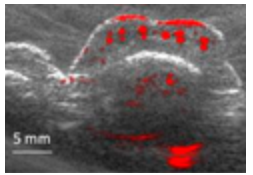
Real time image analysis and data classification for identification of finger joints with high probability of developing arthritis.

COMBINING TECHNOLOGIES

Hyperspectral imaging is a low-cost technology. It will be used for screening in individuals with recent-onset joint pain and thus lead to earlier detection of arthritic disease. This will allow to really take advantage of the well-known “therapeutic window of opportunity” during the first three months after the onset of the disease. Consequently, this will help to prevent both the devastating long-term consequences for the patients (pain, loss of finger function, inability to work) and the high disease associated costs. Preliminary experiments have shown that the most promising spectral region lies between 600 nm and 1200 nm where high contrast between different tissue constituents could be achieved. Development of the overall optical system comprises the identification of a high-sensitivity sensor covering the interesting spectral range and the design of a mechanical system allowing to acquire 3D hyperspectral datacubes with a 2D sensor having one spatial and one spectral dimension. Optoacoustic imaging is a new modality based on laser-generated acoustic waves allowing to visualize the internal structures of soft tissue with functional contrast. It opens a broad field of applications in clinical diagnostics and as a research tool in basic life sciences. Optoacoustic (OA) signal amplitudes correlate with optical absorption, so that even microvasculature with low flow that remains hidden for Doppler ultrasound (US) can be visualized.



Concept sketch of the setup for combined US/OA 3D tomography of fingers.



Combined US/OA cross sectional image of a finger. Structures emitting strong OA signals (blood vessels) are highlighted in red.

Tomographic ultrasound probe based on cMUT transducers.

DIAGNOSIS OF EARLY ARTHRITIS SYMPTOMS

The IACOBUS developments in the field of optoacoustic imaging will bring this technology closer to a clinical routine use. The design of the ultrasound US/OA imaging system is based on an automated 3D scan of fingers, which will overcome the main disadvantages of Doppler ultrasound as a diagnostic tool for arthritic inflammation. This will allow performing routine scans for earlier diagnosis of the disease.

The IACOBUS system uses hyperspectral imaging for overview scanning of the hands and identifying potential sites of joint inflammation. The combined optoacoustic and ultrasound imaging tool allows a detailed investigation of the suspicious joints identified by the hyperspectral imaging tool. The concept of the whole imaging module was designed following the principles of ergonomics and with a view to ease of access and functionality in clinical practice.

IACOBUS can be realized due to the joint effort of internationally recognized partners.

Fraunhofer IBMT assures the overall scientific coordination of the IACOBUS project, develops a suitable multichannel hardware platform for combined US/OA imaging including software and signal processing, and performs the mechanical integration of the system.

IACOBUS KNOW HOW

Norsk Elektro Optikk develops the hyperspectral imaging system for fast overview screening of the hands and coordinates the certification of the hyperspectral imaging module for clinical usage.

VERMON develops a combined US/OA probe with integrated illumination. It is based on innovative cMUT transducers with improved bandwidth and sensitivity.

EKSPLA is responsible for designing, manufacturing, optimization and integration of a tunable wavelength laser source including a fiber optical light delivery system for optimized optoacoustic signal generation.

Norwegian University of Science and Technology contributes to the development and testing of the hyperspectral imaging system, and is in charge of developing algorithms for hyperspectral data analysis.

Justus-Liebig University of Giessen is responsible for conducting the clinical trial to validate the diagnostic device developed.

tp21 is in charge of the iacobus management and communication.

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