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Combined optoacoustic and acoustic tomography system for investigation of fingers

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Arthritic diseases, including rheumatoid arthritis, psoriatic arthritis and osteoarthritis, have a prevalence between 2 and 3% and lead to joint destruction and deformation resulting in a loss of function. Current diagnostic methods rely on B-scan and Doppler ultrasound, x-ray or MRI, which have the drawbacks of low sensitivity and high user-dependency, involvement of ionizing radiation and high costs, respectively. We developed a combined US/OA imaging system for investigation of fingers allowing taking advantage of the high sensitivity of OA for imaging of vasculature and inflammation-related neovascularization.

Our system consists of 4 arc-shapes transducer arrays based on high-bandwidth cMUTs, allowing imaging of all 3 finger joints (full tomographic view of DIP and PIP, top/bottom view of MCP). The pitch of the arrays is 150 µm and the center frequency is around 10 MHz. The total number of 768 elements is connected to a multichannel electronics platform. The system DiPhAS (Digital Phased Array System, Fraunhofer IBMT) has 128 channels for transmit and receive, each allowing the digitization with up to 80 MSamples/s, and has been equipped with a 1 to 8 multiplexer. Signals are generated with a pulsed OPO laser system with a PRF of 100 Hz and a pulse duration of 6 ns (NT232, EKSPLA).

The system´s performance has been evaluated using different phantom structures. The measurements were made on wires directly immersed in the water bath. In addition, tissue phantoms made of PVA, in which bone material was integrated to mimic a real finger were developed. An isotropic resolution of approximately 150 µm was achieved in both modes. The system has furthermore been tested for compliance with MDD 93/42/EEC so that a clinical study can be performed soon.

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Computer assisted detection of polyps during colonoscopy – results from an initial technical study

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The detection of adenomas is one main task during screening colonoscopy, as precursors of carcinomas can be detected and removed. Nevertheless, even though such screening programs have shown positive results in the past years, it can be observed, that still a considerable amount of polyps in the colon are overseen during colonoscopy. Hence, technical developments for the computer assisted detection (CADe) of adenomas and polyps and thus a support of the endoscopist would be quite helpful.

In the past three years a real-time, low-delay software-system based on visual structure, texture, color, and motion features has been developed for the detection of polyps during colonoscopy, which provides visual clues (image augmentation of potential areas with polyps) to the physician. In a technical feasibility study this approach has been tested on patients during routine colonoscopy. The primary goal was the technical feasibility of the system; the secondary goal was the comparison of the polyps as seen by the physician compared to the polyps automatically detected by the system.

Colonoscopic examinations of 58 patients could be captured and analyzed. There were no technical complications based on the software. Of the 75 polyps detected by the physician, 55 (73,3%) polyps were correctly seen by the system. Polyps not detect by the software were quite smaller compared to the polyps seen be the system ($3,6\pm1,6$ mm vs. $7,0\pm7,4$ mm, $p = 0,052$). No polyp smaller than the size of 7 mm have been overseen by the system.

Furthermore, some of the overseen polyps had the tendency of a flat appearance (Paris Nomenclature II) compared to those detected and presented by the system (73,7% vs. 45,8%, $p = 0,054$).

The use of a real-time, low-delay system for a computer-assisted detection of polyps during colonoscopy is possible. 73% of all polyps detected by the endoscopist during this study were also seen by the software. Thus, in the next steps, the automated detection of small and flat polyps shall be addressed.

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3D-Panoramic images for laparoscopy

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Today minimal invasive interventions based on laparoscopy are an established method in the field of surgery. For the patient the trauma, the physical damage of the body as well as the convalescence can thus be reduced. Nevertheless, due to limited and reduced sight such minimal invasive interventions provide various challenges to the surgeons. These challenges include the navigation of the laparoscope inside for the patient's body, the limited orientation in the working space, the partial loss of the third dimension, as well as the reduced view from the so-called "key-hole" intervention. These restrictions can partially be solved by using image processing techniques.

This contribution addresses the compensation of the reduced view by proposing a 3D-panoramic map based on stereo-laparoscopic image sequences. The input data of our approach consist of stereoscopic laparoscopy image sequences acquired during routine laparoscopic surgical interventions. In a first step each dual-frame of the stereo-sequence is rectified in order to find adequate correspondences in both views. Secondly, from each stereo pair frame a depth map is computed using various techniques such as block-matching (BM), semi-global block-matching (SGBM), or the linewise-hybrid recursive matcher (LHRM). Using the thus acquired depth-maps of a moving stereo-laparoscope a 3D-panoramic image can be obtained. To this end, the depth maps from the various laparoscopic views are registered to each other using point-cloud registration approaches such as feature matching (e.g. Brute-Force and FLANN) of extracted 2D or 3D SURF or DOP features combined with a RANSAC outlier filtering. The iterative closest point (ICP) method is optionally applied for a fine alignment step. These fused point clouds are then augmented using the stitched and blended textures from the original laparoscopic image data, this yielding a 3D-panoramic image of the interventional site providing an increased view for the surgeons.

This approach has so far evaluated on various stereoscopic image sequences from plastic and animal knee phantoms
as well as real stereo laparoscopic data from minimal invasive procedures. Currently the complete procedure runs in a conventional PC with approximately 10 fps. Potentially this approach can be achieved in real-time using GPU programming.