ST 1: Biomedical Imaging I

Zeit: Montag 14:00–16:15 Raum: BZ.08.02 (HS 3)

ST 1.1 Mo 14:00 BZ.08.02 (HS 3)

Assessment of Breast Microcalcifications via X-Ray Dark-Field Radiography — •E. Braig[1], K. Scherer[1], L. Binbacher[1], J. Schock[1], K. Willer[1], M. Chabior[1], J. Herzen[2], D. Mayr[3], S. Grandl[4], K. Hellerhoff[4], A. Sztrokay-Gaul[4], F. Bamberg[4], and F. Pfeiffer[1] — [1]Lehrstuhl fur Biomedizinische Physik, Technische Universität München, Garching, Germany — [2]Centre for Materials and Coastal Research, Helmholtz-Zentrum Geesthacht, Geesthacht, Germany — [3]Department of Pathology, Ludwig Maximilian University, Munich, Germany — [4]Department of Clinical Radiology, Ludwig Maximilian University, Germany

Reliable breast cancer detection in clinical mammography is strongly related to the diagnostic evaluation of breast microcalcifications [1]. In conventional mammography however, screening radiologists are restricted to the global appearance of microcalcifications within the mammogram. As a result, visual microcalcification assessment alone is often not particularly meaningful and requires further cost-intensive invasive procedures. In this study we revolutionize current microcalcification analysis by providing a clinically practicable tool for sub-resolution microcalcification assessment which utilizes the dark-field (scattering-based) contrast[2]. We were able to qualtitatively classify the mircostructure of microcalcifications as ultra-fine, fine, pleomorphic and coarse textured and verify our results by comprehensive high resolution MicroCT measurements. Our approach yields the potential to enhance cancer risk stratification with the final goal of avoiding unnecessary medical follow-up.

ST 1.2 Mo 14:15 BZ.08.02 (HS 3)

Enabling lower dose by redefining the lower statistical limit in X-ray phase-contrast computed tomography — •Mathias Marschner[1], Michael Chabior[1], Lorenz Birnbacher[1], Marian Willner[1], Julia Herzen[1], Peter B. Noël[2], and Franz Pfeiffer[1,2] — [1]Lehrstuhl für Biomedizinische Physik, Physik-Department & Institut für Medizintechnik, Technische Universität Müunchen, 85748 Garching — [2]Institut für diagnostische und interventionelle Radiologie, Klinikum rechts der Isar, Technische Universität München, 81675 Müunchen, Germany

Phase-contrast X-ray computed tomography (PCCT) is currently investigated and developed as a potentially very interesting extension of conventional CT, because it promises to provide high soft-tissue contrast for weakly absorbing samples. For data acquisition, several images at different grating positions are combined to obtain a phase-contrast projection. For short exposure times, the photon counts in a single stepping position are very low. In this case, the currently used phase-retrieval does not provide reliable results for some pixels or the phase retrieval breaks down completely and the phase information is lost. We examine the statistical properties of a linear approximation method and illustrate by simulation and experiment that the lower statistical limit can be redefined using this method. That means that the phase signal can be retrieved even with very low photon counts and statistical phase wrapping can be avoided. This is an important step towards enhanced image quality in PCCT with very low photon counts.

ST 1.3 Mo 14:30 BZ.08.02 (HS 3)

Significance enhancement of phase-contrast and dark-field signals — •Veronika Ludwig, Jens Rieger, Georg Pelzer, Thomas Weber, Thilo Michel, and Gisela Anton — Friedrich-Alexander-Universität Erlangen-Nürnberg

The topic of my Master thesis is to improve the significance of the phase-contrast and dark-field signals resulting from microcalcifications in mammography images. For that purpose, different methods of statistical image analysis were used. The talk will give an overview of the approaches to improve the SNR and CNR, to reduce uninteresting artifacts like edge effects and to enhance microcalcification structures. Besides the common image processing tools such as median filtering, the application of the gray-level co-occurrence matrix and Minkowski functionals were used. Finally, the results for the best combination of methods are shown and an outlook is given.

ST 1.4 Mo 14:45 BZ.08.02 (HS 3)

Correlation of X-Ray Micro-CT with X-Ray Tensor Tomography — •Christoph Jud, Florian Schaff, Friedrich Prade, and Franz Pfeiffer — TU München, München, Deutschland

X-Ray Tensor Tomography (XTT) is a novel tomographic reconstruction technique that yields information about the orientation of subpixel sized structures. It is based on the dark-field signal, a contrast modality measured with a so called Talbot-Lau grating interferometer. Dark-field images are a measure for the small and ultrasmall angle scattering. With XTT, the scattering tensors can be reconstructed fully in three dimensions.

In order to verify XTT measurements, its correlation to state of the art micro-CT was investigated. Several well-known fibrous samples were used for the investigation. Since small-angle scattering mainly occurs orthogonal to fibres, the XTT data could be simplified to a vector-field which indicates the fibre direction. A framework was implemented, allowing the direct comparison of both the XTT and the micro-CT datasets. Registration of the datasets was done using a commercial visualization software. A key part of the framewok was the extraction of structure directions out of micro-CT data. This was done with different algorithms including a commercial fibre tracking software. The correlation was then quantitatively investigated by measuring the intermediate angle between both vectorfields. A qualitative comparison was done by visualizing both vectorfields simultaneously. A correlation was found for different sample types and different structure orientations.

ST 1.5 Mo 15:00 BZ.08.02 (HS 3)

Advanced X-ray image quality enhancement with the single-photon-counting LAMBDA detector — •Stephan Kaczmarz — Lehrstuhl für Biomedizinische Physik E17, James-Franck-Strasse 1 85748, Garching

In this work, the LAMBDA imaging system with the hybrid CMOS based Medipix3RX readout architecture is used and image quality improvements investigated. Besides numerous advantages like spectral information as well as the absence of dark current and readout noise, inevitable production tolerances of the small detector electronics can cause a decreased image uniformity. Additionally, the influence of the sample itself further degrades the image quality by beam hardening.

Therefore, this work probes the performance of the advanced Signal-to-equivalent-thickness calibration (STC) in comparison with the commonly used Flatfield-correction for bio-medical and material testing applications. The basic idea of STC is to translate the photon count-rate of a Raw image to a reference absorber thickness pixel-wise by a previously gained calibration map.

The results demonstrate the great performance of STC. Beam hardening can be drastically reduced as well as cupping artifacts in a CT scan. Sample features emerge that were not recognizable before as the image uniformity in increased. Furthermore, CdTe-sensor growing domain artifacts are completely removed and STC gives rise to image informations that were overlaid by those artifacts before. To sum up, STC greatly improves the absorption based X-ray image quality without increasing the applied radiation dose.

ST 1.6 Mo 15:15 BZ.08.02 (HS 3)

Simultane Rekonstruktion der Verteilungen des Absorptionskoeffizienten, Brechungsindexes und Dunkelfeldstreukoeffizienten mittels Likelihood-Maximierung in der Röntgen-Talbot-Lau-Tomographie — •André Ritter, Thomas Weber, Andreas Wolf und Gisela Anton — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen Centre for Astroparticle Physics (ECAP), Erwin-Rommel-Str. 1, 91058 Erlangen

Ein Verfahren zur simultanen Rekonstruktion der Verteilungen des Absoprtionskoeffizienten, Brechungsindexes und Dunkelfeldstreukoeffizienten in der Talbot-Lau-Tomographie wird vorgestellt. Ausgehend von Schätzungen dieser drei Verteilungen werden die erwarteten Phasenabtastwerte bestimmt. Iterativ wird die Likelikood der Phasenabtastwerte maximiert und somit die Schätzung an die Wahrheit angenähert.

Die Rekonstruktion kann auf simulierte und gemessene Daten angewendet werden und bietet mehrere Vorteile. Das Verfahren kann auch auf Daten mit weniger als drei Phasenabtastwerten pro Winkelschritt angewendet werden. Die Vorhersage von Phasensprüngen (Phasewraps) ist im Bildgebungsmodell der Rekonstruktion vorhanden und führt nicht zu Artefakten. Die Rekonstruktion bietet einen Rahmen,

um das Bildgebungsmodell der Talbot-Lau-Interferometrie zu testen und zu erweitern. Die Aussagekraft und Eindeutigkeit der rekonstruierten Verteilungen, insbesondere für polychromatische Aufbauten und große Proben, wird so verbessert werden.

ST 1.7 Mo 15:30 BZ.08.02 (HS 3)

Tilted grating phase-contrast computed tomography — •Lorenz Birnbacher, Marian Willner, Mathias Marschner, Julia Herzen, and Franz Pfeiffer — Lehrstuhl für Biomedizinische Physik, Physik-Department & Institut für Medizintechnik, Technische Universität München

An X-ray Talbot-Lau interferometer consists of three gratings which have parallelly oriented grating lines. Via shifting one of those gratings perpendicularly with respect to its grating orientation - the so-called phase-stepping - one measures the differential phase-contrast (DPC) signal of structures in scanning direction (perpendicular to the grating lines). However, due to the grating orientation the DPC signal is insensitive in the direction of the grating lines (parallel to the grating lines).

One approach to overcome this loss of sensitivity is to tilt the gratings by 45 degrees with respect to the tomography axis and perform a tomographic scan during a full sample rotation. Combining two corresponding DPC projections of 0 and 180 degrees with a two-directional integration algorithm, a phase projection sensitive in both directions can be retrieved leading to a fully sensitive tomographic scan of 180 degrees.

We show the results of this method using a high-sensitivity phase-contrast computed tomography (PC-CT) setup and compare the results with standard PC-CT scans with respect to feature detectability of biomedical samples.

ST 1.8 Mo 15:45 BZ.08.02 (HS 3)

Improved spatial resolution of X-ray phase-contrast computed tomography via iterative image deconvolution — •Fabio De Marco, Lorenz Birnbacher, Marian Willner, Mathias Marschner, Julia Herzen, and Franz Pfeiffer — Lehrstuhl für Biomedizinische Physik, Physik-Department & Institut für Medizintechnik, Technische Universität München

In a grating-based phase-contrast computed tomography (PC-CT) setup, differential phase data is retrieved by laterally scanning one grating of the Talbot-Lau interferometer. From the resulting set of images, a projection for each of three modalities (attenuation, differential phase and darkfield) is calculated.

The resolution of the stepping images (and by extension, the tomographic reconstructions), is limited mainly by the source size and the detector response. Their impact can be described as a convolution of the undisturbed image with the system's point-spread function (PSF). Having measured the shape of this PSF, a deconvolution can be performed to approximate the undisturbed image.

We examined the ability of several deconvolution algorithms to counteract these resolution-limiting effects. The algorithms were applied to the stepping images of CT scans of biological soft-tissue samples. The resolution of tomographic reconstructions is improved significantly, especially in the phase-contrast modality. The boundaries between tissue types are sharpened, which increases the number of recognizable features. However, an increase of noise is observed for all employed algorithms. The impact on quantitative values is also discussed.

ST 1.9 Mo 16:00 BZ.08.02 (HS 3)

Tissue decomposition using grating-based phase-contrast computed tomography (PC-CT) — •Manuel Viermetz, Lorenz Birnbacher, Marian Willner, Mathias Marschner, Julia Herzen, and Franz Pfeiffer — Lehrstuhl für Biomedizinische Physik, Physik-Department & Institut für Medizintechnik, Technische Universität München

Talbot-Lau interferometry provides three complementary imaging modalities, the conventional attenuation contrast, the differential phase-contrast signal which has enhanced soft tissue contrast and the dark-field signal which is related to small angle sample scattering. This technique which is also available with laboratory X-ray sources in a setup consisting of three gratings is used for computed tomography for each of these modalities.

The ability to access the refractive index decrement and the linear attenuation coefficient in one registered measurement enables advanced evaluation methods of tissue properties. We focus on the quantitative tissue analysis based on the complementary attenuation and phase-contrast information to assess the fractions of lipid, protein and water in the sample. The concept of decomposition using PC-CT is evaluated for recently acquired imaging results of biomedical samples and phantoms.