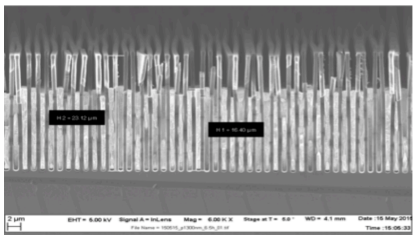


SWISS LIGHT SOURCE SLS

SLS Symposium on

Biology and medicine

Tuesday, June 14, 2016

10:00 to 12:15, WBGB/019

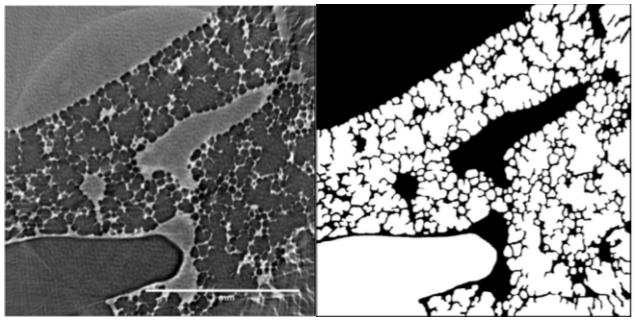
10:00 Design and construction of a phase-contrast mammography prototype for the in-vivo investigation of breast cancer
Carolina Arboleda, Z. Wang, T. Koehler, G. Martens, U. van Stevendaal, M. Bartels, E. Roessl, P. Villanueva-Perez, K. Jefimovs, L. Romano, M. Kagias and M. Stampanoni

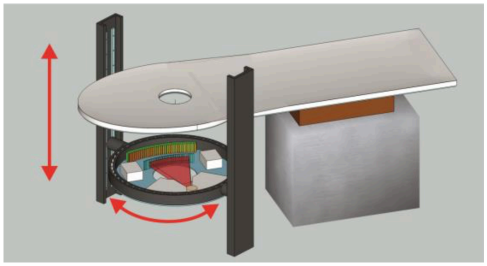
10:30 Automatized 3D Segmentation of acinar microstructure
Ioannis Vogiatzis Oikonomidis, T. P. Cremona, G. Lovric, F. Arcadu, C. M. Schlepütz, R. Mokso, M. Stampanoni and J. Schittny

11:00 Coffee

11:15 Towards the development of an X-ray phase contrast breast CT scanner.
Maria Buechner, Z. Wang and M. Stampanoni

11:45 Microfluidic System for Trapping Nano-objects
Deepika Sharma, M. Gerspach, T. Pfohl, R. Lim, Y. Ekinci.





Design and construction of a phase-contrast mammography prototype for the in-vivo investigation of breast cancer

Carolina Arboleda[1,2], Zhentian Wang[1,2], Thomas Koehler[3], Gerhard Martens[3], Udo van Stevendaal[3], Matthias Bartels[3], Ewald Roessl[3], Pablo Villanueva-Perez[1], K. Jefimovs[1], L. Romano[1], M. Kagias[1,2] and Marco Stampanoni[1,2]

[1]Paul Scherrer Institute, 5232 Villigen, Switzerland, [2]ETH Zurich, 8092 Zurich, Switzerland, [3]Philips Research Laboratories, D-22335 Hamburg, Germany

This project consists of the development of a grating-based phase contrast mammography prototype for the in-vivo investigation of breast cancer. Clinically, we aim at improving the diagnostic power of mammography by exploiting the additional information provided by differential phase and dark-field signals. To this end, our approach is to design and build a grating interferometer (GI) that can be fitted into a Philips Microdose Mammography setup, which already fulfills the requirements of a clinical setting [1,2]. To define the parameters of this GI, we developed an optimization method based on maximizing the sensitivity to phase and dark-field changes taking into account the geometric and grating fabrication constraints. The phase sensitivity was defined as the minimum detectable electron density gradient, whereas the dark-field sensitivity was expressed as the dark-field signal-to-noise ratio [3]. In addition, we investigated alternatives to retrieve and reconstruct the new additional signals that can be compatible with the Philips setup acquisition mode [4].

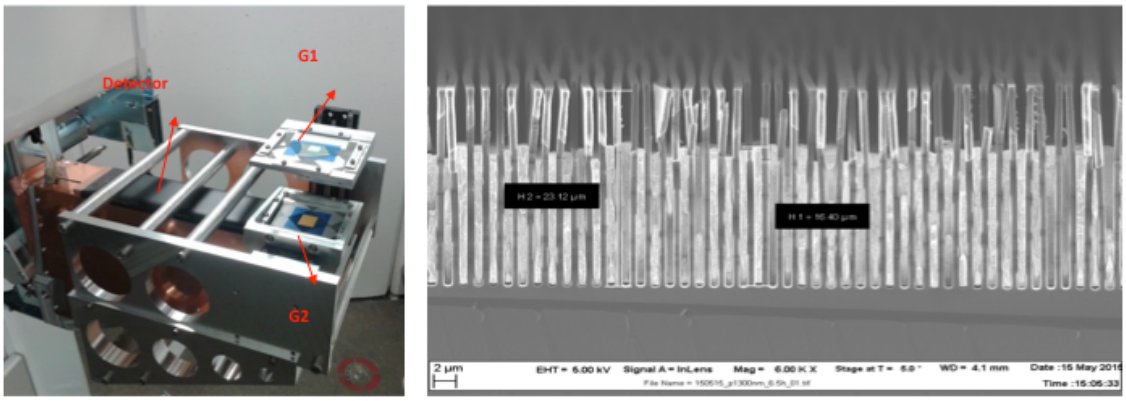


Figure 1. Left: GI on the Philips Microdose Mammography Setup. Right: Gold grating with p_2=1.3 µm, a height of 16 µm and a duty cycle of 0.5.

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[3] Arboleda C, Wang Z, Koehler T, Martens G, van Stevendaal U, Daerr H, Bartels M, Villanueva-Perez P, Roessl E and Stampanoni M 2016 Sensitivity-based optimization for the design of a grating interferometer for clinical X-ray phase contrast mammography (In preparation)

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AUTOMATIZED 3D SEGMENTATION OF ACINAR MICROSTRUCTURE

Ioannis Vogiatzis Oikonomidis[1,2], Tiziana P. Cremona[1], Goran Lovric[2,4], Filippo Arcadu[2,3], Christian M. Schlepütz[2], Rajmund Mokso[2], Marco Stampanoni[2,3] and Johannes Schittny[1]

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Abstract

The lung is one of the live supporting organs and the acinus represents its functional unit. There is limited knowledge on the acinar 3D microscopic dynamics during breathing and development. Using synchrotron based X-ray tomographic microscopy the 3D lung structure can be resolved with micrometer resolution. Moreover, recently we have proven the feasibility of ex-vivo and in-vivo measurements at different pressures [1]. This kind of data is mainly characterized by low contrast to noise ratio (CNR) and local tomography artifacts. In addition, the structures to be resolved are on the resolution limit and present high structural complexity, i.e. large size variation within a slice, no clear shape descriptor and no clear borders between different acini on 2D sections. As a result, an accurate segmentation of the structure, which is the prerequisite to extract the acinar skeleton, represents a very challenging task.

Here we propose an automatized algorithm for 3D segmentation of the reconstructed volume of lung tissue at the micrometer scale, which enables the extraction of the acinar skeleton and the quantification of the breathing and development patterns of the acinus. A combined multilevel filtering approach without any manual input is adopted. This approach efficiently yields accurate segmentations of volumes with very poor CNR levels by taking into account the 3D structure. The proposed method first applies a connected component analysis of an initial Otsu threshold segmentation, followed by a vesselness filter [2] aimed at generating per slice-automatized seeds for a random walk [3]. The septa regions (white pixels in fig 1) have the same ID on the whole volume and the information of adjacent slices is thus used to determine if an undetermined voxel is an opening in the septa region or not. Essentially, the strategy is to mimic the way the human eye classifies regions (tissue or air) by scrolling between adjacent slices.

As a result, our method manages to accurately segment thin septa that define the borders of the acini, whose correct description is mandatory for a reliable acinar skeleton. This is the first step to study how the lung breathes and develops at a micrometer scale. This approach can be applicable to other geometries with large size variations within a single slice like foam or heart vessel walls.

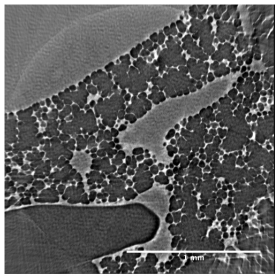

Figure 1. Reconstruction.

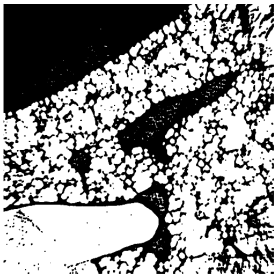

Figure 2. Initial segmentation.

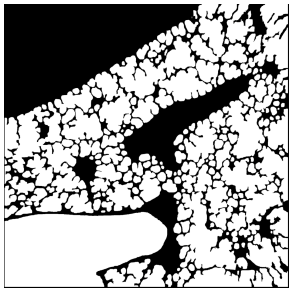

Figure 3. Final segmentation.

References

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Towards the development of an X-ray phase contrast breast CT scanner

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Breast cancer is the leading cause of cancer death among women and one of the most frequently diagnosed cancer, representing 23% of the overall cancer cases and 14% of cancer death [1]. Mammography, based on X-ray absorption imaging, is the standard diagnostic tool for breast cancer detection. However, it is limited in its diagnostic capabilities with respect to early cancer detection due to low soft tissue contrast. It is further limited as it only reveals two dimensional information, and the resulting tissue overlapping reduces the detectability of breast lesions.
One way to increase the contrast is to go from absorption-based imaging to phase contrast imaging (PCI) since the phase shift of the X-ray wave front is significantly larger [2]. Further combining PCI with computed tomography (CT) imaging will allow precisely locating lesions in three dimensional structures, thus revealing weakly absorbing structures hidden in dense tissue.
There are several PCI techniques which differ in the recorded signal, illumination requirements and experimental setup. Grating interferometry (GI) is an interferometric method using a combination of diffraction and absorption gratings to retrieve both the absorption and phase signals. GI can be operated in a compact setting using polychromatic and only weakly spatially coherent X-rays, allowing the use of conventional X-ray tubes, thus potentially enable the implementation of phase contrast breast CT (bCT) in clinical settings.

The development of such a pre-clinical bCT system brings together both scientific and mechanical challenges. In this work, we will give an overview of our developments and solutions to address those challenges. From a scientific point of view one open question is the design and performance of an optimized GI system for breast CT, while considering medical restrictions like maximal allowed dose, minimal lesion detectability and maximal scan duration, and considering technical aspects like maximal achievable resolution, overall efficiency of the system and fabrication restrictions. As both signal retrieval as well as reconstruction algorithms for phase contrast CT still undergo active development, the development, evaluation and possible improvement of i.e. phase contrast spiral CT algorithms and novel phase retrieval algorithms will be part of the overall system optimization. From a mechanical point of view two major challenges have to be addressed. First, highly precise and stable rotation and translation of the complete bCT gantry is necessary to fulfill the stability requirements of the GI and comply with resolution and contrast demands for medical applications. Secondly, the design and construction of a compact and easy to use positioning system is essential in developing a bCT system, since the GI system requires precise alignment and stable positioning of its individual components.

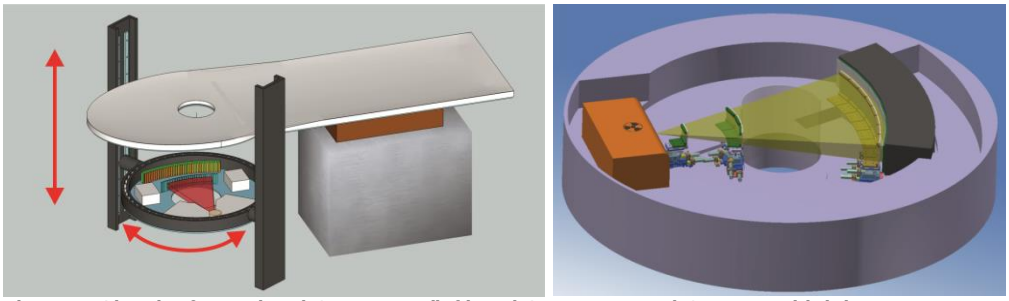

Figure 1: Sketch of complete bCT system (left) and GI concept on bCT gantry (right).

References

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Microfluidic System for Trapping Nano-objects

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Geometry-induced electrostatic (GIE) trapping has been shown to be a robust platform for the temporary, contact-free, immobilization of nano-objects enabling the study of their dynamics. In comparison to conventional trapping methods, this technique doesn't require external power source and fully relies on the electrostatic forces inside the smartly designed microfluidic chamber. For GIE-trapping of nano-objects, we are fabricating a microfluidic device with nanometric traps using conventional fabrication techniques. To understand the distribution of electrostatic forces within and around the traps, we are performing simulations that are further used for trap-design optimization to achieve steeper potential wells with longer trapping time.