A quantification of iodine contrast in mammography spectral X-ray imaging with a 300ÂµmSi photon-counting pixel detector

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Abstract

X-ray mammography is an important part of the breast cancer diagnosis chain. A lot of mammography examinations are done preventatively. Recent developments within the field of digital mammography (DM) provide more accurate diagnosis of breast cancer, compared with analogue mammograms. DM plays an increasing role in diagnosis of early stage breast tumours.
To diagnose early stage tumours, the visibility of tumour-like materials inside the breast is important. Due to the small X-ray absorption differences between tumour tissue and glandular tissue, the detectability of tumour cells is limited. On top of that the malignant tissue, especially in an early stage of cancer, can be very subtle and may be obscured by the normal glandular tissue. In this case an improvement between the contrast of the malignant tissue and normal tissue is desirable. This is achieved by intravenous injections (IV) of iodinated contrast agents. This methodology is called contrast enhanced digital mammography (CEDM). CEDM is very useful since it has been shown that the growth of breast cancer can be indicated by a relative large amount of blood vessels in an area. Those vessels are created by the body to supply the tumour with oxygen and nutrients that are required for its further development. This new microvessels are highlighted by contrast agents. Contrast agents thus enhance contrast in the region surrounding the tumour. Over time a few techniques have been proposed and developed to make use of CEDM. The core task is to make iodine distinguishable from all surrounding tissues, so that a tumourous region is highlighted. Spectral X-ray information is a promising factor in highlighting contrast agents.
The aim of this work is to test whether spectral sensitivity in the sensor will enhance contrast in contrast enhanced digital mammography examinations. This is tested by fitting a model of the X-ray source and detector system with data. This data is gathered by a 2x2 cm2 , 300Âµm-Si thick sensitive layer in combination with a Timepix chip.
Two methods have been used to quantify the results: KES and spectral KES.
Both KES and spectral KES methodologies are compared to Baldelli et al. and Zhu et al. respectively. Those experiments provide clinical results based of a few free parameters: dose, pixel size, area. In a clinical KES system the detection limit came out on 5.75 mg I/ml. In this situation the mammography experiment using KES would have measured a detection limit of 2.18 mg I/ml. For the spectral KES methodology the clinical limit is set on 0.65 mg I/ml, assuming that a CNR of 3 is acceptable. Taking the circumstances as in Zhu et al., the detection limit for the mammography-like experiment would have been 0.22 mg I/ml. Both KES and spectral KES methodology thus do better compared to clinical examinations. With that in mind a sensitive layer of 300Âµm GaAs should have done another factor of 2.6 better compared to a 300Âµm Si sensor. Also the use of a different anode/filter combination possibly bring another improvement of counting statistics in the iodine K-edge energy range. Future experiments thus should focus on both testing other sensitive layers and anode/filter combinations to further decrease the detection limit of iodine.