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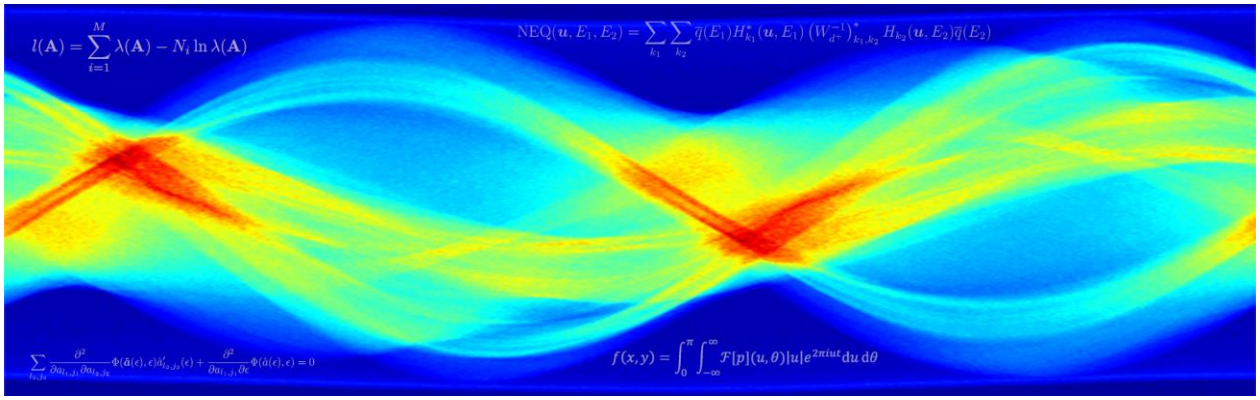
MSc thesis projects in photon-counting CT research

Mats Persson, Department of Physics, KTH; mats.persson@mi.physics.kth.se

Below are some examples of possible projects, but this is not an exhaustive list. If you are interested please contact me to discuss ideas more in detail!



A calibration method for high-precision photon-counting computed tomography

Photon-counting computed tomography, with its higher resolution and improved energy resolution, promise to be able to generate x-ray attenuation maps with substantially improved quantitative accuracy compared to existing CT scanners. In order to achieve this goal, however, it is necessary to develop improved reconstruction methods that are able to compensate for a variety of physical nonidealities, such as charge sharing, Compton scatter in the object and detector and geometric blur. Since it is difficult to develop perfect physics models of all these effects, it is necessary to develop sophisticated calibration schemes. In this project, we will develop an new calibration and correction method based on scanning test objects ("phantoms") and applying statistical methods, including deep learning, to use these measurements to correct errors in CT images. This new method will be applied to data from a photon-counting CT scanner prototype based on technology developed in our research group.

The resulting quantitative CT imaging method has the potential to be a large step towards truly quantitative photon-counting CT imaging, which can make data-driven radiological science much more effective than before, by allowing measurements to be compared between images acquired in different institutions, for different patients and with different scanner settings, thereby enabling more effective data-sharing for developing AI diagnosis tools.

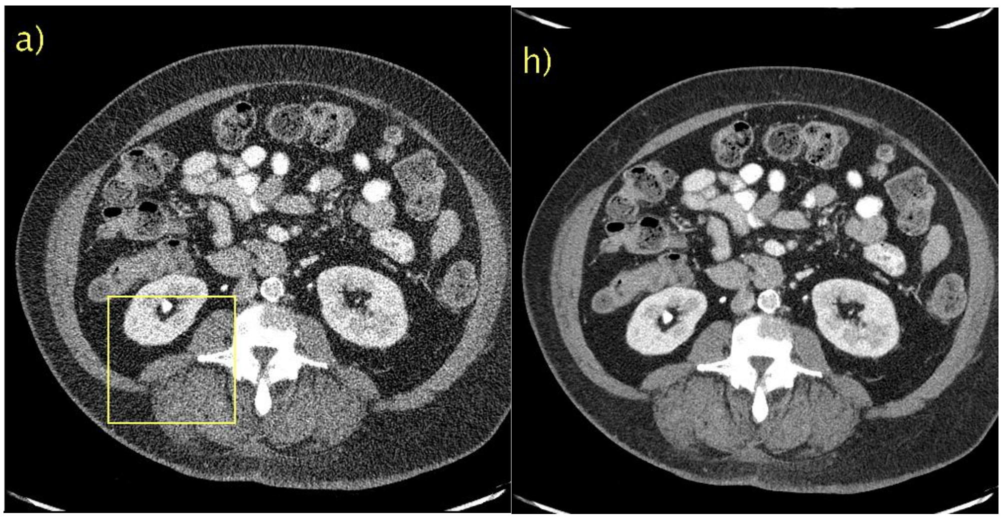
Development and validation of deep-learning based image reconstruction methods for photon-counting CT

In recent years, deep-learning-based image reconstruction has shown impressive performance with respect to noise reduction and computational speed. In our research group at KTH, we have developed a deep-learning-based denoising method for photon-counting CT images based on recent developments in AI research, namely deep learning methods such as score-based diffusion models and Poisson flow models, and initial results show that this outperforms the previous state of the art. In this MSc thesis project, you will take part in further developing this method in order to reach its full potential for improving medical image quality. Potential topics include

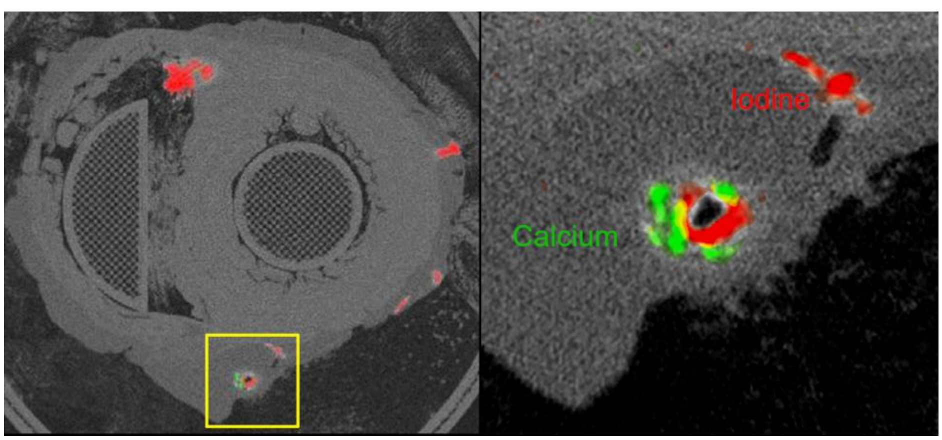
- Adapting the denoising method for ultra-low dose imaging, thereby enabling novel medical applications such as lung cancer screening with negligible patient dose

- Improved material decomposition to differentiate between calcium and iodine, an important task in imaging of cardiovascular disease.
- Applying deep learning in the raw data domain, thereby eliminating the need for an analytical image reconstruction step before denoising.

The new methods will be tested on data from a prototype next-generation photon-counting CT scanner based on technology developed within our research group. A successful project in any of these areas has will have the potential of being impemented in the clinic and become an important aid for tomorrow's medical professionals.



Photon-counting CT image before (left) and after (right) denoising with PPFM, a deep-learning denoising method developed within our research group (D. Hein et al. https://arxiv.org/pdf/2312.09754.pdf)



Excised heart specimen imaged with a deep-silicon photon-counting detector. F. Grönberg, J. Lundberg et al. Eur Radiol. vol. 30, 5904–5912, Jun 2020