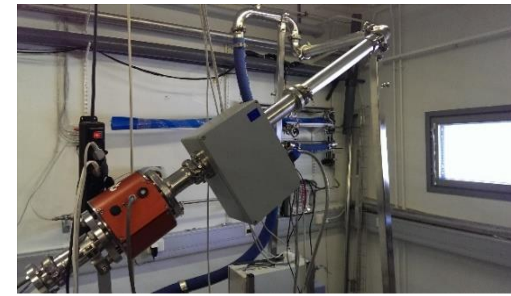
Doctoral researcher (PhD student) positions in Computational Physics and Inverse Problems

University of Eastern Finland
Department of Technical Physics
Kuopio campus

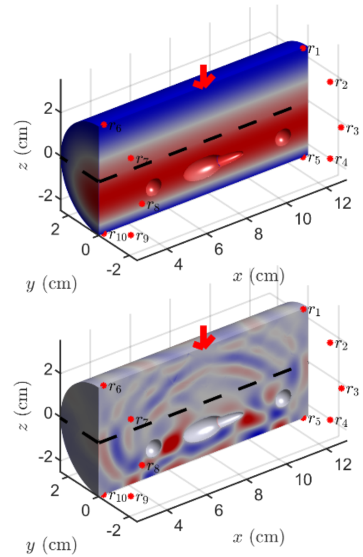
Finnish Centre of Excellence in Inverse Modelling and Imaging
2018-2025

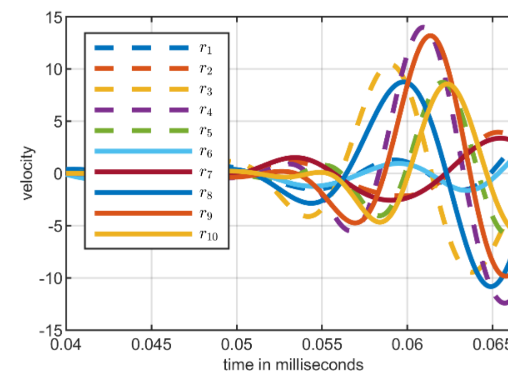
1. Tomographic multimodal imaging of three-phase flow

This PhD thesis project focuses on creating environmental-friendly, non-ionizing measurement technology for real-time imaging of three-phase flows within the process industry. Understanding, prediction and measurement of such flows are key to the overall efficiency and safety of industrial processes.



Here, we aim to advance the characterization of three-phase flow by employing a tomographic multimodal imaging approach. Novel image reconstruction and measurement techniques are developed to combine ultrasound, electrical, and electromagnetic flow tomography techniques to a unique multimodal imaging technology.





With the proposed approach, it is possible to estimate the flow velocities and volumetric flow rates of different phases in real-time, enabling better monitoring and control of process flows in various industrial applications.

Supervisors: Prof. Marko Vauhkonen and research director Timo Lähivaara

Collaborating institutions: HZDR Dresden, Germany and Tianjin University, China

2. Quantitative photoacoustic tomography

European Research Council
Established by the European Commission

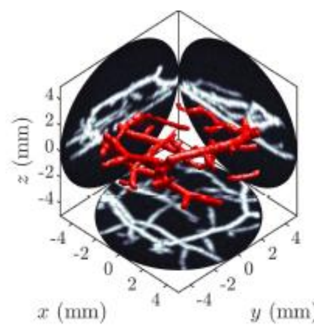
The topic of this PhD thesis project is development of computational modelling and inverse problems methodologies for quantitative photoacoustic tomography.

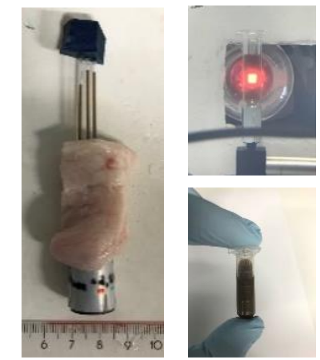
Quantitative photoacoustic tomography is a coupled physics imaging modality combining optical (near-infrared light) and acoustic (ultrasound) phenomena. In the technique, photoacoustic effect is utilised to reconstruct images of the distribution of light absorbers in tissues.

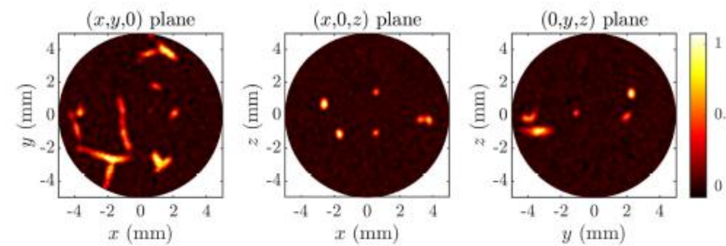
Here we aim at computational modelling of light and ultrasound propagation as well as development of computational and machine learning methodologies for efficient image reconstruction and uncertainty quantification in quantitative photoacoustic tomography.

Supervisor: Prof. Tanja Tarvainen, PhD

Collaborating institutions: University College London, United Kingdom, Martin-Luther-Universität Halle-Wittenberg, Germany







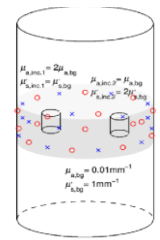
3. Diffuse optical tomography

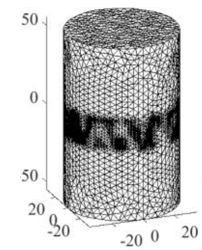
European Research Council
Established by the European Commission

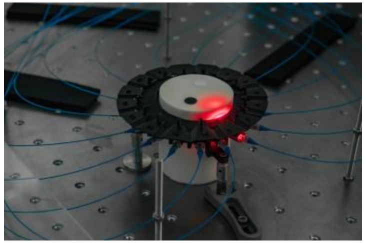
In this PhD thesis project, the aim is to develop computational methods for modelling and inverse problem of diffuse optical tomography.

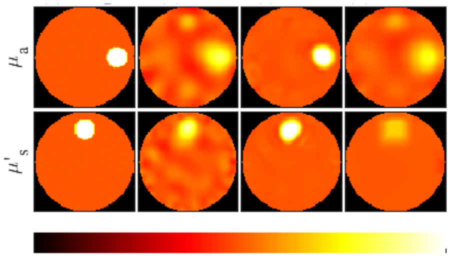
Diffuse optical tomography is an imaging modality where images of optical properties of tissue reconstructed from light transport measurements made on the boundary of the target. This image reconstruction a highly ill-posed inverse problem that needs to be approached using methods of computational inverse problem.

In this project, we aim at developing efficient methods for image reconstruction utilising computational modelling and machine learning. The main applications of interest are in imaging of brain and breast cancer.



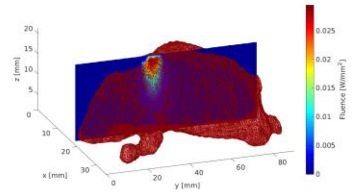






Supervisors: Prof. Tanja Tarvainen and PhD Meghdoot Mozumder

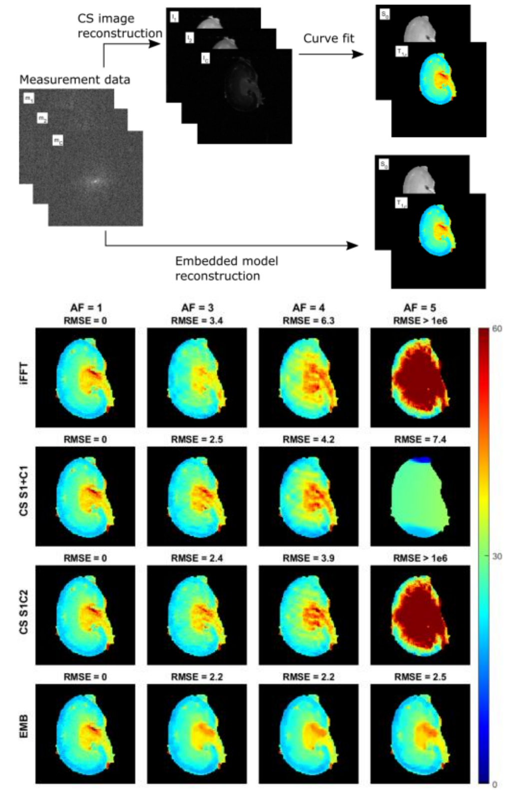
Collaborating institutions: University College London, United Kingdom



ValoMC
Visible and near infrared light transport on mesh based geometry

4. Accelerated model-based multiple contrast quantitative MRI

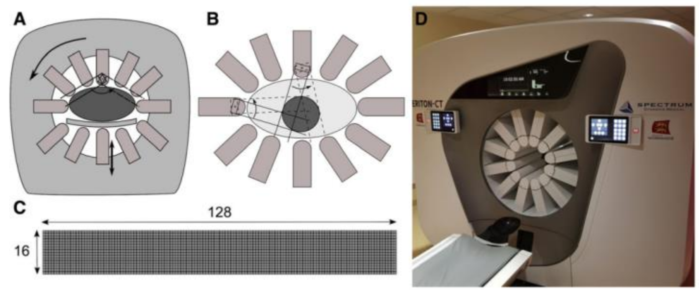
- This PhD project aims at significantly accelerating quantitative magnetic resonance imaging by utilizing non-linear embedded model-based image reconstruction of multiple quantitative contrasts simultaneously. Enabling minimized acquisition-maximum information encoding would allow gaining maximum clinical information from MRI scans.
- The project builds on previous developments on embedded model-based reconstruction of quantitative MRI contrasts, with the aim to increase the number of clinically relevant quantifiable parameters by an innovative combination of novel MRI imaging protocols and inverse problems solution techniques.
- *Supervisors*: Prof. Ville Kolehmainen, Prof. Mikko Nissi, Olli Nykänen PhD



Hanhela M et al 2022, J Imaging

5. Computational methods for enhancing quantitative cardiac imaging with novel digital 3D SPECT systems

- The aim in the project is to develop advanced, quantitative cardiac nuclear imaging by an innovative combination of inverse problems mathematics and low radiation dose dynamic imaging data from new generation 3D digital single photon emission computed tomography and computerized tomography (SPECT/CT) imaging.
- In the development of the CS (compressed sensing) based SPECT algorithms, the main research tasks are the development of a tailored 4D space-time regularization model for cardiac applications and modification of Poisson noise statistics into the CS based algorithm.
- Key factor in this project is the utilization of novel digital 3D SPECT technology (see image, installed in Kuopio University Hospital 2023) in the reconstruction development including unique possibility to focus image acquisition during patient studies.
- The performance of the developed algorithm will be evaluated with low dose SPECT data from the numerical simulations and the clinical SPECT/CT examinations.
- *Supervisors:* Prof. Ville Kolehmainen, Prof. Marko Vauhkonen, Adj. Prof. Mikko Hakulinen (Diagnostic Imaging Center, Kuopio University Hospital)

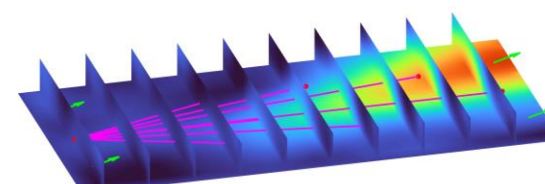


Desmonts et al 2020, EJNMMI Physics

6. Monitoring of fugitive greenhouse gas emissions in biogas production using laser dispersion tomography

In Finland, the future aim is to widely increase the utilization of cow manure, to produce biomethane for fuel. The production is planned to be done in farms which invest for bioreactors. Naturally, the biogas production is designed to cause very low emissions from the reactors and during the transport of gas. However, verification of the low emission rate is important.

The aim of the project is to develop a new technique, laser dispersion tomography, for localizing and quantifying potential leaks in biogas plants. This technique uses a rotating laser source which sequentially scans a set of retroreflectors (special mirrors) installed in the plant site, and gives spatial averages of the gas concentration along the lines connecting the source and the retroreflectors. Based on such data, and computational modelling, the spatio-temporal distributions of the gas concentration and leak sources are reconstructed.



In addition to developing computational methods, the thesis work will include experimental field work in the biogas production plants.

Supervisors: Prof. Aku Seppänen, PhD

Collaborating research institutes: Natural Resources Institute Finland (Luke), Rutherford Appleton Laboratory, UK.