Course 1: Model-based medical image analysis

In biomedical image analysis we often would like to quantify physiological parameters such as tissue oxygenation, or reliably detect the presence of subtle fluorescent biomarkers showing the spread of cancerous cells. This can be difficult because the relationship between image pixel values and the information that we seek is not straightforward.

This course will introduce the concept of image formation modelling and a range of novel model-based techniques that can overcome these difficulties. Most problems will be drawn from optical imaging in the visible and infrared range on various scales, from intra-cellular microscopy to macro-imaging of tissues and organs.

The course will start from developing physical fundamentals, showing how an image is build by the transfer of energy (photons, waves, ...) from a source, through the interactions with tissues (refraction, absorption, scatter, ...) to the detectors of an imaging system. Practical use will be made of computational techniques such as Monte Carlo simulations. The course will then introduce a range of model-based analytical techniques including image restoration, the quantification of physiological parameters through model inversion, the imaging of tissues "transparent" to visible light (phase-contrast imaging), spectral unmixing for samples tagged with multiple fluorescent markers and the use of image formation models for the optimisation of image acquisition parameters. The students will also learn the basics of established image processing techniques such as image reconstruction from projections, image registration, processing of temporal sequences and tracking.

The course will consist of lectures, hands-on lab assignments and will conclude with a team-work competition for developing a solution to a practical problem. The participants are expected to be competent Matlab users.