ALPEN-ADRIA UNIVERSITÄT KLAGENFURT

Invitation to the Doctoral Seminar

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“Enabling robust quantitative photoacoustic tomography via learned image reconstruction, digital twins, and fast models”

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Abstract

In this talk we present a practical example on how the framework of learned image reconstruction can help to overcome practical challenges in solving real-world inverse problems and what is needed to formulate a robust learned reconstruction method. Specifically, we consider photoacoustic tomography, where a biological tissue is illuminated with a short laser pulse of near infrared light. The absorbed energy creates a local pressure increase that propagates through the tissue, governed by the acoustic wave equation, and we can measure the pressure wave on the boundary. From this measured time-series we first aim to reconstruct the initial pressure in the tissue, providing valuable information on local structures, such as microvasculature. Subsequently, it is possible to recover quantitative optical parameters of absorption and scattering. Correct recovery of the optical parameters would provide valuable functional and biological information for medical purposes.

In practice, solving both the acoustic and optical inverse problem comes with challenges. Including an often encountered limited-view geometry,

restricting the measurement surface and resulting in a mild to severely ill-posed linear inverse problem for the acoustic inversion. Additionally, modelling errors and uncertainties complicate an accurate recovery of the optical parameters. The above challenges can be effectively mitigated by training a learned reconstruction method, but three crucial ingredients are necessary: a learned method with good generalisability for out-of-distribution data, a computationally fast model to allow for feasible training and inference times, and finally reference data for the training procedure. These three points are here approached by using a learned model-based iterative reconstruction, with fast approximate models including a novel FFT based approach to solve the acoustic problem for circular geometries. And finally, training and evaluation using a digital twin providing a link between experimental and simulated data. Experimental examples are presented for the acoustic problem and first results for the optical problem using the digital twin data.

Elena Resmerita and the Department of Mathematics look forward to seeing you at the talk!