Master Thesis Opportunities at the Quantitative Molecular Imaging Lab

Advancing quantitative molecular imaging through *simulation* and *machine learning*.

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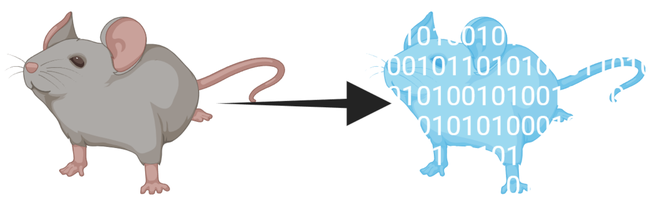
(1) Numerical Mouse Disease Models

Goal: Develop realistic digital mouse models to reduce the need for physical animal experiments in imaging research. Simulations must reflect anatomical and pathological features, which current models lack.



Challenge: This project integrates a tumour model into healthy mouse anatomies by learning from multi-scale photoacoustic data (mesoscopic and tomographic data).

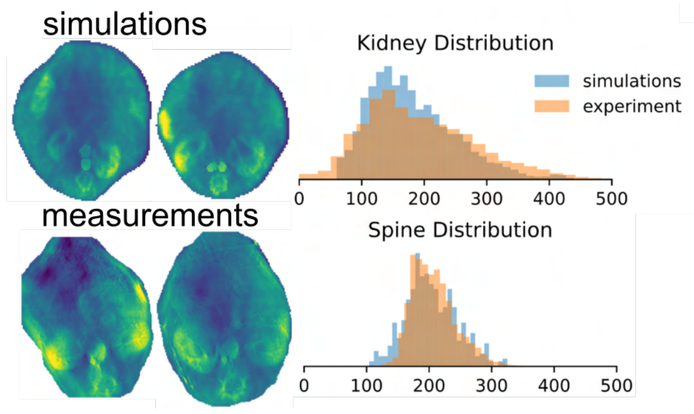


Figure: *Preliminary data from healthy digital mouse model.*
Left: *Simulated vs real photoacoustic images.*
Right: *Quantitative value distributions in different organs.*

(2) Disease-aware semantic image segmentation

Goal: Identify a training strategy that enables the accurate muscle segmentation in ultrasound and photoacoustic data of patients suffering from neuromuscular diseases.

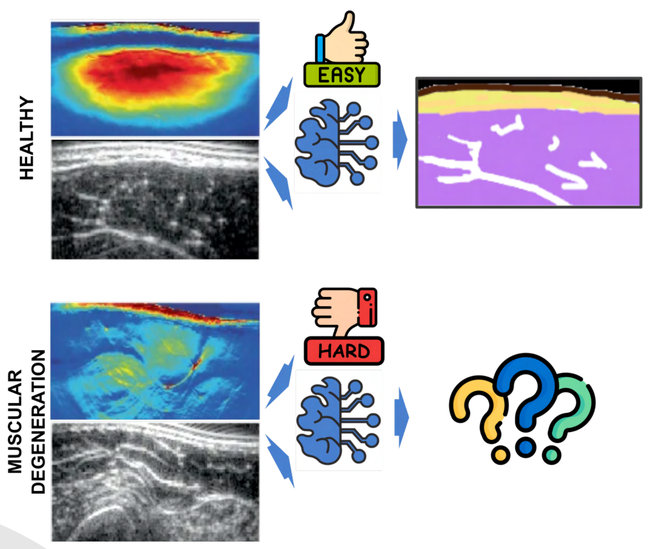


Figure: *While it is easy to semantically annotate images from healthy volunteers, even medical experts can struggle to annotate images of patients suffering from muscular degeneration.*

Challenge: Semantic annotation of neuromuscular diseases is difficult due to scarce annotated data and high inter-patient heterogeneity.

This project investigates the generalisation performance of established semantic segmentation models and develops post-training adaptation strategies to improve segmentation accuracy in ultrasound and photoacoustic imaging.

Interested?
Let's get in touch!

(3) RL-based simulation optimisation

Goal: Conduct a proof-of-principle study to determine whether reinforcement learning can be used to optimise unknown simulation parameters in a photoacoustic imaging pipeline, using real-world image data and known ground truth structures.

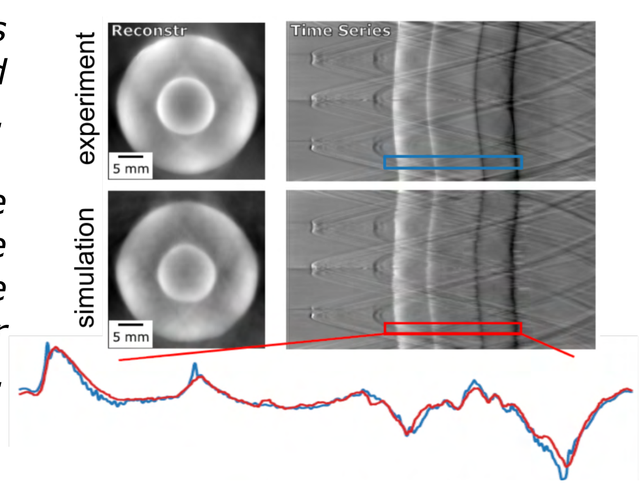


Figure: *Preliminary results of an end-to-end simulation gap reduction.*

While the initial results are promising, they underscore the need for more interpretable, modular optimisation strategies.

Challenge: Simulation pipelines often depend on hand-tuned parameters, such as the impulse response, noise characteristics, light source properties, or detector characteristics, which are not accurately known in practice.

This project explores whether reinforcement learning agents can automatically adapt simulation settings to minimize the mismatch between real and simulated images, using image similarity as a reward signal.

Collaboration with:

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https://eni-g.de/groups/quantitative-molecular-imaging