Implementation of machine learning (i.e. Bayesian Optimisation) and computer vision for melt electrowriting (MEW)

Master's thesis

(Section: Computer Science – Materials Science – Software Engineering – 3D Printing)

Over the last two decades, additive manufacturing (3D printing) has been gaining significant attention in tissue engineering and biofabrication research as a versatile class of manufacturing technologies. This primarily stems from its ability to fabricate unique patient-specific designs as well as fabricate structures from a wide range of biomaterials.[1] For biomedical applications, high resolution 3D printing techniques, such as melt electrowriting (MEW) have been favoured for their exceptional ability to replicate the fine features and complex microarchitecture of native tissues to mimic both their structure and function.[2] To date MEW research often utilises pressure-driven extrusion methods on custom devices built by individual research groups, processing the most common polymer in MEW poly(caprolactone) (PCL).

At the LMIS1, we are currently investigating a novel filament-based extrusion system, which has many advantages over the current standard due to the possibilities in modification and customisation.[3] A current research gap is in the control of the print on-the-fly, while monitoring it, and reacting to environmental factors. This thesis will contribute to the implementation of a visual system, linked to Bayesian optimisation (BO[4]) for on-the-fly corrections of the print and precision control over the resulting fibres.
The topic is highly multidisciplinary, involving aspects of engineering, computer and materials science: the focus can be adjusted depending on the student's preferential interests, best knowledge, previous experience and motivation. (Fundamental) knowledge of BO is a must, but can be expanded upon with literature study.

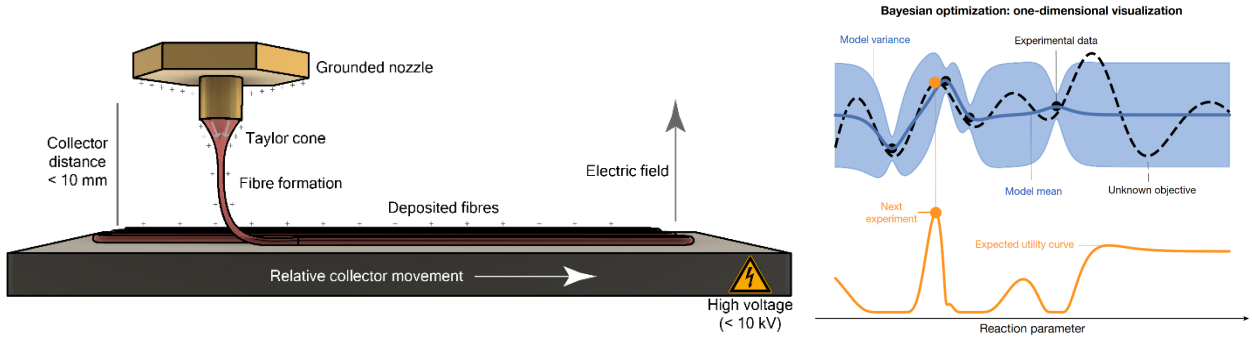

Figure 1 : *(left) schematic showing the principles behind melt electrowriting (MEW), (right) graphical overview of Bayesian optimisation, taken from ref 4.*

Possible tasks:

- Improvement of a computer vision system for the printer (Raspberry pi based)
- Implementation of BO analysis of manufactured fibres (further development of previous study)
- Implementation of on-the-fly adaptation of parameters of MEW (such as extrusion rate, voltage and printing speed……)
- SEM characterisation of finalised scaffolds on modern instruments

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[1] B.P. Chan, K.W. Leong, *Eur Spine J*, **2008**, *17*, 467-479.
[2] J.C. Kade, P.D. Dalton, *Adv Healthcare Mater*, **2021**, *10*, 2001232.
[3] A. Reizabal, *et al.*, *Addit Manuf*, **2023**, *71*, 103604.
[4] B.J. Shields, *et al.*, *Nature*, **2021**, *590*, 89.

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