Optimization of additively manufactured polymer scaffolds for bone tissue engineering

Patrick Dondl*

* Abteilung für Angewandte Mathematik
Albert-Ludwigs-Universität Freiburg
Hermann-Herder-Str. 10, 79111 Freiburg i. Br, Germany
e-mail: patrick.dondl@mathematik.uni-freiburg.de, web page: https://aam.uni-freiburg.de/agdo/

ABSTRACT

Additive manufacturing (AM) is a rapidly emerging technology that has the potential to produce personalized scaffolds for tissue engineering applications with unprecedented control of structural and functional design. Particularly for bone defect regeneration, the complex coupling of biological mechanisms to the scaffolds properties has led to a widespread trial-and-error approach. To mitigate this, shape or topology optimization can be a useful tool to design a scaffold architecture that matches the desired design targets, albeit at high computational cost.

Here, we consider two complementary approaches: first, an efficient macroscopic optimization routine based on a simple one-dimensional time-dependent model for bone regeneration in the presence of a bioresorbable polymer scaffold is developed. The result of the optimization procedure is a scaffold porosity distribution which maximizes the stiffness of the scaffold and regenerated bone system over the regeneration time, so that the propensity for mechanical failure is minimized. This part of the presentation is based on [1].

Second, we consider a periodic microstructure optimization problem for scaffold architectures based on a domain-splitting. This part of the presentation is based on [2].

REFERENCES

[1] Poh, P.S.P., Valainis, D., Bhattacharya, K., van Griensven, M., and Dondl, P., "Optimizing Bone Scaffold Porosity Distributions", *arXiv:1809.08179* (2018).

[2] Dondl, P., Poh, P.S.P., Rumpf, M., and Simon, S., "Simultaneous elastic shape optimization for a domain splitting in bone tissue engineering", *arXiv:1809.07555* (2018).