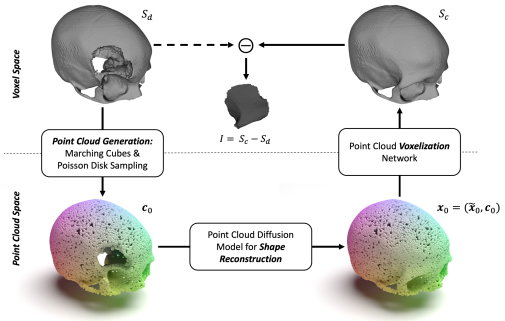
University of Basel
Department of
Biomedical Engineering

University of Basel, Department of Biomedical Engineering, Center for medical Image Analysis and Navigation (CIAN), Hegenheimermattweg 167b/c, 4123 Allschwil, Switzerland

Master of Science – Biomedical Engineering, Thesis Proposal

## Improved Point Cloud Diffusion Models for Automatic Implant Generation

Advances in 3D printing of biocompatible materials make patient-specific implants increasingly popular. The design of these implants is, however, still a largely manual and time-consuming process, which is usually carried out by trained experts. To automate and speed up this design process, we developed an automatic deep learning solution presented in [1]. The method consists of a point cloud diffusion model for shape reconstruction and a voxelization network. For further information on the developed method check out the project page: https://pfriedri.github.io/pcdiff-implant-io/.




Due to the iterative sampling process of the used Denoising Diffusion Probabilistic Model (DDPM, T=1000) and computationally expensive postprocessing steps, the time required for generating an implant is around 25-30 minutes, which we aim to speed up significantly. This goal could be achieved by applying different sampling strategies [2, 3] or distillation methods [4], adapting the used conditioning strategy of the method (namely by using less points for conditioning), by applying a different network architecture or by using a more efficient implementation of the postprocessing steps (mainly the undercut removal). The student should try to reduce the runtime of the overall method, while keeping the good implant quality and the methods low memory footprint. The goal of this thesis would be to implement and compare different “speed-up methods”, to adapt the existing code base accordingly, and to conduct extensive experiments to verify the success of the applied changes.

### Nature of the Thesis
Programming: 80%, Documentation: 20%

### Specific Requirements
Experience in deep learning & good programming skills *(Python/ PyTorch)*

### Supervisors
Dr. Julia Wolleb*, University of Basel, Center for medical Image Analysis and Navigation (CIAN)*
Paul Friedrich (PhD student)*, University of Basel, Center for medical Image Analysis and Navigation (CIAN)*

### Contact
paul.friedrich@unibas.ch

### References
[1] Friedrich, P., Wolleb, J., Bieder, F., Thieringer, F.M., Cattin, P.C. (2023). In Medical Image Computing and Computer Assisted Intervention – MICCAI 2023.
[2] Song, J., Meng, C., & Ermon, S. (2020). Denoising Diffusion Implicit Models. In International Conference on Learning Representations – ICLR 2020.
[3] Karras, T., Aittala, M., Aila, T., & Laine, S. (2022). Elucidating the design space of diffusion-based generative models. In Advances in Neural Information Processing Systems – NeurIPS 2022.
[4] Song, Y., Dhariwal, P., Chen, M., & Sutskever, I. (2023). Consistency models. In International Conference on Machine Learning – ICML 2023.

University of Basel
Department of Biomedical Engineering
Gewerbestrasse 14
4123 Allschwil, Switzerland

Prof. Philippe C. Cattin
Center for medical Image Analysis and
Navigation (CIAN)
T +41 61 207 54 00
philippe.cattin@unibas.ch