

Master student project: Generative AI model for spine 3D images generation

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Location: Balgrist University Hospital, Forchstrasse 340, 8008 Zurich

Project duration: 6 months

Project start: October 2023

Project Description:

Given patient healthcare data privacy concerns, high quality medical images datasets for research are a scarce resource. Thus, the current development of generative artificial intelligence (AI) models for medical image generation are of high interest, since they potentiate the creation of synthetic datasets (Jordon et al., 2022), which, themselves, bear no privacy concerns. Recently, such approach was taken by teams in King's College London in collaboration with Nvidia¹ to generate thousands of synthetic 3D brain magnetic resonance imaging (MRI) scans (Tudosiu et al., 2022). This new model and produced datasets are being used for synthetic *in-silico* modelling of cerebral pathologies.

The proposed master thesis project aims at exploring different libraries of generative AI models (Khader et al., 2023; Tudosiu et al., 2022; Zhou et al., 2021, 2019) for the creation of spine synthetic datasets. These synthetic datasets will then be evaluated by medical professionals and be used for segmentation and biomechanical modelling (Caprara et al., 2021; Isensee et al., 2021; Sekuboyina et al., 2021). For model development, both on-site and cloud computational resources will be available.

The project will initiate with a bibliographical review of the status-of-the-art of generative AI and its applicability to biomedical data, with focus on images. Follows a compilation of suitable open-source datasets for different spine segments image generation, i.e., cervical, thoracic, and lumbar. The raw dataset will then be used to train a spine generative model given the chosen architecture. The end goal of the

¹ <https://www.nvidia.com/en-us/>

project resides in the deployment of the generative model in a cloud setting powered by MONAI Label² and Slicer3D³, allowing for direct visualization of the generated images.

The DMU and the Department of Radiology are looking for a motivated master student with a background in biomedicine and/or computational sciences good python, scripting skills, knowledge in machine learning and interest in working at the interface between machine learning and medical applications.

For applications, please send your curriculum, course transcripts, and a letter of motivation to rui.ramos-santos@balgrist.ch together with the information of one reference contact.

References:

- Caprara, S., Carrillo, F., Snedeker, J.G., Farshad, M., Senteler, M., 2021. Automated Pipeline to Generate Anatomically Accurate Patient-Specific Biomechanical Models of Healthy and Pathological FSUs. *Front. Bioeng. Biotechnol.* 9.
- Isensee, F., Jaeger, P.F., Kohl, S.A.A., Petersen, J., Maier-Hein, K.H., 2021. nnU-Net: a self-configuring method for deep learning-based biomedical image segmentation. *Nat. Methods* 18, 203–211. <https://doi.org/10.1038/s41592-020-01008-z>
- Jordon, J., Szpruch, L., Houssiau, F., Bottarelli, M., Cherubin, G., Maple, C., Cohen, S.N., Weller, A., 2022. Synthetic Data -- what, why and how?
- Khader, F., Mueller-Franzes, G., Arasteh, S.T., Han, T., Haarbuerger, C., Schulze-Hagen, M., Schad, P., Engelhardt, S., Baessler, B., Foersch, S., Stegmaier, J., Kuhl, C., Nebelung, S., Kather, J.N., Truhn, D., 2023. Medical Diffusion: Denoising Diffusion Probabilistic Models for 3D Medical Image Generation.
- Sekuboyina, A., Hussein, M.E., Bayat, A., Löffler, M., Liebl, H., Li, H., Tetteh, G., Kukačka, J., Payer, C., Štern, D., Urschler, M., Chen, M., Cheng, D., Lessmann, N., Hu, Y., Wang, T., Yang, D., Xu, D., Ambellan, F., Amiranashvili, T., Ehlke, M., Lamecker, H., Lehnert, S., Lirio, M., Olaguer, N.P. de, Ramm, H., Sahu, M., Tack, A., Zachow, S., Jiang, T., Ma, X., Angerman, C., Wang, X., Brown, K., Kirszenberg, A., Puybureau, É., Chen, D., Bai, Y., Rapazzo, B.H., Yeah, T., Zhang, A., Xu, S., Hou, F., He, Z., Zeng, C., Xiangshang, Z., Liming, X., Netherton, T.J., Mumme, R.P., Court, L.E., Huang, Z., He, C., Wang, L.-W., Ling, S.H., Huynh, L.D., Boutry, N., Jakubicek, R., Chmelik, J., Mulay, S., Sivaprakasam, M., Paetzold, J.C., Shit, S., Ezhov, I., Wiestler, B., Glocker, B., Valentinitsch, A., Rempfler, M., Menze, B.H., Kirschke, J.S., 2021. VerSe: A Vertebrae labelling and segmentation benchmark for multi-detector CT images. *Med. Image Anal.* 73, 102166. <https://doi.org/10.1016/j.media.2021.102166>
- Tudosiu, P.-D., Pinaya, W.H.L., Graham, M.S., Borges, P., Fernandez, V., Yang, D., Appleyard, J., Novati, G., Mehra, D., Vella, M., Nachev, P., Ourselin, S., Cardoso, J., 2022. Morphology-Preserving Autoregressive 3D Generative Modelling of the Brain, in: Zhao, C., Svoboda, D., Wolterink, J.M., Escobar, M.

² <https://monai.io/label.html>

³ <https://www.slicer.org/>

(Eds.), *Simulation and Synthesis in Medical Imaging*, Lecture Notes in Computer Science. Springer International Publishing, Cham, pp. 66–78.
https://doi.org/10.1007/978-3-031-16980-9_7

Zhou, Z., Sodha, V., Pang, J., Gotway, M.B., Liang, J., 2021. Models Genesis. *Med. Image Anal.* 67, 101840. <https://doi.org/10.1016/j.media.2020.101840>

Zhou, Z., Sodha, V., Rahman Siddiquee, M.M., Feng, R., Tajbakhsh, N., Gotway, M.B., Liang, J., 2019. Models Genesis: Generic Autodidactic Models for 3D Medical Image Analysis, in: Shen, D., Liu, T., Peters, T.M., Staib, L.H., Essert, C., Zhou, S., Yap, P.-T., Khan, A. (Eds.), *Medical Image Computing and Computer Assisted Intervention – MICCAI 2019*, Lecture Notes in Computer Science. Springer International Publishing, Cham, pp. 384–393.
https://doi.org/10.1007/978-3-030-32251-9_42