Doctoral School of Information and Biomedical Technologies
Polish Academy of Sciences (TIB PAN)

SUBJECT: Generative Neural Network Architectures for Synthetic Breast MRI: Method Development and Downstream Task Evaluation

SUPERVISOR: Jan Mielniczuk, professor, Institute of Computer Science, PAS

DESCRIPTION:

Breast magnetic resonance imaging [1] (MRI) is characterized by high diagnostic sensitivity and pronounced anatomical and signal heterogeneity, making it a powerful but technically challenging modality for the development of artificial intelligence (AI)–based diagnostic tools. The progress of deep learning methods for breast MRI is currently limited by the availability of large, diverse, and well-balanced datasets, as well as by legal and organizational barriers to clinical data sharing.

Generative deep learning models constitute a promising approach to addressing data scarcity and data sharing limitations in medical imaging by enabling the generation of synthetic datasets that retain diagnostically relevant information while mitigating privacy risks. Recent advances in generative adversarial networks (GANs) [2] and latent diffusion models (LDMs) [3] have demonstrated their capability to produce high-quality synthetic medical images. Nevertheless, the application of these methods to high-resolution, three-dimensional, multiparametric breast MRI data [4] remains largely underexplored. In addition, there is a lack of systematic studies assessing the effectiveness of synthetic MRI data for training deep neural networks in downstream tasks such as segmentation, classification, or further image generation. This project aims to address these challenges through the development and training of novel generative deep learning architectures for synthetic breast MRI data and through a comprehensive evaluation of the usability of such data in downstream learning tasks.

The successful candidate will be a member of the research team of Dr. Andrzej Liebert at the Institute of Computer Science, PAS, which works on AI methods for medical imaging. The project has additional funding from the SONATA grant (NCN) “GENIE-MRI: Generative Neural Networks for Image Exchange in Breast MRI”, No. 2024/55/D/ST6/02310. After admission to the doctoral school, the candidate may apply for an NCN doctoral scholarship funded from this grant (5000 PLN monthly for a period of 3 years) in an additional open recruitment procedure.

Key tasks of the project include:

1. Developing and training deep generative models’ architectures (GANs and LDMs) using Python and PyTorch.
2. Investigating methods for conditioning synthetic image generation using clinical data
3. Evaluating synthetic data quality using quantitative metrics (e.g., SSIM, FID) and qualitative expert reader studies.
4. Testing the usability of synthetic data for training of AI models for classification, segmentation, and other downstream tasks.

Candidate Requirements:

1. A Master’s degree (M.Sc.) in Computer Science, Biomedical Engineering, or a related discipline.
2. Proficiency in Python programming with focus on frameworks for deep learning and image processing such as PyTorch, MONAI, Simple ITK, Pandas.
3. Preferentially, experience in one or more of the following areas:
    a. Implementation and training of neural networks.
    b. Experience with training of image generation deep learning methods.
    c. Medical image processing or working with MRI data.
4. A strong motivation to contribute to cutting-edge research in biomedical imaging and AI.

Candidates should contact Dr. Andrzej Liebert (Andrzej.liebert@ipipan.waw.pl) and Prof. Jan Mielniczuk (jan.mielniczuk@ipipan.waw.pl) before formal submission of documents.

BIBLIOGRAPHY:

1. Mann RM, Cho N, Moy L. *Breast MRI: State of the Art*. Radiology. 2019;292(3):520–536.
2. Goodfellow I et al. *Generative Adversarial Nets*. NeurIPS 2014.
3. Rombach R, Blattmann A, Lorenz D, Esser P, Ommer B. *High-resolution image synthesis with latent diffusion models*. CVPR 2022.
4. Garrucho L et al. *A large-scale multicenter breast cancer DCE-MRI benchmark dataset with expert segmentations.* Sci Data 12, 453 (2025). https://doi.org/10.1038/s41597-025-04707-4.
5. Shumailov I et al. *AI models collapse when trained on recursively generated data*. Nature. 2024.