Degree project 30 credits in Biomedical Engineering

Embedding Time in Generative Models for Temporal Medical Image Synthesis

Biomedical Engineering R&D (MT-FoU) is a research and development department at the Center for Information Technology and Biomedical Engineering at Norrland University Hospital, Region Västerbotten. The department conducts international research, development and education in the field of biomedical engineering, with expertise in, for example, sensors and measurement systems, image and signal analysis and biomechanical models. MT-FoU is also a part of the competence center AI for Medicine in Northern Sweden, AIM North, which supports clinical research projects with technical method expertise in machine learning and AI.

Background

Generative Artificial Intelligence (AI) has emerged as a powerful tool for medical imaging, with applications in image synthesis, translation between modalities, and data augmentation. Beyond single time-point imaging, an exciting frontier is the ability to generate **longitudinal sequences** of medical images that capture disease progression or treatment response. Such models could support prognosis, reduce data scarcity, and provide new tools for simulation. Recently, diffusion models and other generative frameworks have shown remarkable ability to synthesize realistic and clinically meaningful images. Extending these methods to **temporally-aware modeling**, capturing changes between consecutive scans, offers the potential to simulate disease evolution across multiple time points. However, research in this area is still in its early stages.

Aim of the project

The aim of this thesis is to **embed temporal information into generative AI models for longitudinal medical imaging**. By integrating time as an explicit component of the modeling process, the project seeks to generate realistic follow-up scans that reflect disease progression and treatment response. The focus will be on developing, adapting, and evaluating temporally-aware generative models (e.g., diffusion models, conditional GANs) to improve predictive imaging and broaden applications such as prognosis support, data augmentation, and virtual disease progression modeling.

Work description

The thesis will involve the following main tasks:

1. **Literature Review**: survey state-of-the-art approaches in generative AI for medical imaging, with emphasis on temporal and longitudinal modeling.
2. **Data Preparation**: Select and preprocess longitudinal imaging datasets (e.g., CT, MRI) suitable for temporal generative modeling.
3. **Model Development**: Implement or adapt a generative model that explicitly incorporates temporal information (e.g., via latent space conditioning, time embeddings, or contrastive alignment).
4. **Evaluation**: Quantitatively evaluate generated images using technical metrics (PSNR, SSIM, FID, task-based metrics), Qualitatively assess realism and clinical plausibility with medical expert input.
5. **Documentation and Reporting**: Document methodology, experiments, and findings in a structured thesis report.

Prerequisites: basic programming skills in Python, familiarity with concepts in Machine Learning/Deep Learning, Pytorch (optional but beneficial). A preliminary phase will involve theoretical and practical study aimed at filling the necessary skill gaps.

Supervisors at MT-FoU
Paolo Soda, Francesco Di Feola
CIMT, Medicinsk teknik – FoU
Region Västerbotten
E-post: paolo.soda@umu.se, francesco.feola@umu.se
Web: https://www.regionvasterbotten.se/medicinsk-teknik-forskning-och-utveckling