Degree project 30 credits in Biomedical Engineering

Evaluating and Extending X-GeM: An In-House Multimodal Foundation Model for Medical Data Generation

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

The adoption of Artificial Intelligence in medical imaging holds great promise but remains hindered by challenges such as data scarcity, privacy constraints, and the need for robust multimodal data integration. Generative modelling has emerged as a promising solution, enabling synthetic data generation for augmentation and anonymization purposes. To address these challenges, we developed XGeM, a 6.77-billion-parameter multimodal generative model capable of synthesizing chest X-rays and radiological reports jointly. Unlike existing unimodal or unidirectional approaches, XGeM enables any-to-any synthesis across modalities via a shared latent space and Multi-Prompt Training strategy. Initial validation on the MIMIC-CXR dataset demonstrated state-of-the-art performance, with positive results in both benchmark metrics and expert radiologist evaluations. While these results are promising, testing and adapting XGeM beyond MIMIC-CXR is crucial, to ensure clinical robustness and generalizability. To this end, this thesis will focus on validating and adapting XGeM on external datasets, covering different data modalities and anatomical districts.

Aim of the project

The aim of this thesis is to **evaluate and adapt XGeM on external medical datasets** covering diverse data modalities and anatomical districts, with a focus on testing generalization, robustness, and adaptability to new clinical contexts. Specific objectives include:
1) Benchmarking XGeM against external datasets of chest X-rays and radiological reports.
2) Investigating domain adaptation strategies (fine-tuning, prompt adaptation, data harmonization).
3) Assessing the realism and clinical alignment of generated data under distribution shifts.

Work description

The project will consist of the following tasks:

1. **Dataset Preparation**: select and preprocess medical datasets.
2. **Model evaluation on external data**: Test baseline performance of XGeM on unseen datasets, analysing limitations and performance gaps compared to baseline performance.
3. **Domain adaptation**: Implement fine-tuning strategies for adapting XGeM to unseen data distributions (prompt adaptation, contrastive re-alignment, or lightweight transfer learning).
4. **Quantitative and qualitative validation**: Benchmark model outputs with standardized evaluation metrics (e.g., FID, BLEU, clinical report metrics). Conduct expert-based assessments where feasible to evaluate clinical realism.
5. **Documentation and Reporting** Document methodology, adaptation strategies, and results in a final 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