Degree project 30 credits in Biomedical Engineering

Foundation Model Embeddings and XAI for Interactive Longitudinal Patient Trajectory Analysis

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

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Longitudinal biomedical imaging, such as repeated CT or MRI scans, provides key insights into how diseases progress under treatment. Comparing these temporal trajectories across patients is challenging due to high data dimensionality and heterogeneous evolution patterns.

Foundation models trained on large-scale biomedical datasets can extract embeddings that capture relevant spatial and temporal features, enabling clustering of patients with similar trajectories. To make these analyses clinically meaningful, an interactive Human-Machine Interface (HMI) is required. Such a system should allow clinicians to visualize trajectories, identify subgroups of patients with similar evolution, and apply explainable AI (XAI) methods to highlight the features that drive differences between groups.

Aim of the project

This project aims to develop an interactive HMI for longitudinal biomedical imaging analysis. The objectives are:

1. Extract embeddings from foundation models applied to longitudinal sequences.
2. Cluster patients according to temporal disease evolution.
3. Visualize trajectories and subgroup similarities through an interactive interface.
4. Integrate XAI to explain which imaging features or temporal patterns distinguish different patient groups.

The resulting system will combine representation learning, clustering, and explainability into a user-friendly tool to support clinical interpretation of longitudinal data.

Work description

1. **Literature Review:** Survey methods for longitudinal imaging, foundation models, clustering, and XAI.
2. **Dataset Preparation:** Preprocess longitudinal biomedical imaging datasets.
3. **Embedding Extraction:** Generate embeddings from foundation models at multiple time points.
4. **Trajectory Clustering:** Group patients based on embedding similarity across time.
5. **HMI Development:** Implement an interface for trajectory visualization, subgroup exploration, and interactive comparisons.
6. **XAI Integration:** Apply explainability methods to identify the features and time points that explain differences between subgroups.
7. **Evaluation:** Test the system on real datasets and refine it based on clinical feedback.
8. **Reporting:** Document methods, design, and results in the thesis report.

Supervisors at MT-FoU

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