Degree project 30 credits in Biomedical Engineering

Exploring MAMBA architecture for emphysema detection

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

Recent advancements in deep learning have rised significant interest in State Space Models (SSMs), which originated from the classic Kalman filter. These models are particularly effective in handling long sequences due to their convolutional and near-linear computational efficiency. A particularly notable recent advancement is the MAMBA architecture, which introduces time-varying parameters into the SSM. MAMBA has demonstrated good performance in scaling tasks, showing great potential as an alternative to Transformers, particularly in the field of language modeling. Given MAMBA's success in language modeling, there is a growing interest in extending its application to the visual domain. Vision MAMBA (Vim) was introduced as an adaptation of MAMBA for visual tasks. Vim incorporates bidirectional SSMs to model global visual context and introduces position embeddings for spatial awareness, making it robust in dense prediction tasks like object detection and segmentation. The superior efficiency of MAMBA allows for large-scale visual representation pretraining at lower computational costs, positioning Vim as a competitive alternative to CNNs and Vision Transformers. In medical imaging, particularly in diseases like emphysema, accurate detection and classification are crucial for early diagnosis and effective treatment. Traditional deep learning models, such as CNNs and ViTs, have made strides in medical image analysis, but they face limitations in handling the large-scale, high-resolution nature of medical images. The introduction of an SSM-based architecture like MAMBA into this domain could offer significant advantages in capturing long-range dependencies and improving the efficiency of medical image analysis, potentially enhancing emphysema detection.

Aim of the project

This project aims at exploring the application of MAMBA architecture for emphysema detection in medical imaging. Specifically, the project will focus on adapting the Vision-MAMBA architecture to process CT scans, leveraging its ability to capture long-range dependencies.

Work description

The key objectives and tasks for this project include:

1. **Literature review:** Investigate current state-of-the-art approaches that leverage the MAMBA architecture for medical imaging applications.
2. **Data Preprocessing:** preprocess CT scans belonging to the SCAPIS cohort. This step includes the segmentation of the lung regions using a pre-trained segmentator.
3. **Algorithm development:** Implement a MAMBA-based vision model by leveraging public code repositories, making necessary modifications and optimizations to tailor the algorithm for our specific medical imaging task.
4. **Training and Validation:** Train the adapted MAMBA-based model on the preprocessed dataset. Evaluate its performance using metrics such as accuracy, sensitivity, specificity, and AUC-ROC, comparing its performance against traditional CNN and Vision Transformer models.
5. **Reporting and Documentation:** document all stages of the project, including methods, results, and insights gained, producing a final report.

If your program has 15 credits rather than 30, we will adapt the scope of the thesis to fit within the credits.

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