Degree project 30 credits in Biomedical Engineering

Test-Time-Adaptation for medical decision support systems

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

Supervised learning has long struggled with generalizing under distribution shifts, where the training and test data come from different distributions. Even minor differences between these datasets can cause state-of-the-art models to underperform. This issue is particularly prominent in the medical field, where models trained on specific types of medical images or patient demographics often fail when applied to different populations or imaging conditions. This mismatch leads to a significant drop in performance, raising serious concerns for clinical applications where reliable generalization is critical.

Aim of the project

This project seeks to explore Test-Time-Adaptation (TTA), a technique designed to address the challenge of distribution shifts by allowing pre-trained models to adapt to new, unlabeled data from the target domain before making predictions. Unlike traditional approaches, TTA accesses the test data during the test phase, enabling dynamic adaptation to the target distribution. The goal is to move beyond the static, fixed decision boundary typically used during testing. Instead, the project aims to blur the line between training and testing, aiming for continuous learning and adaptation even after deployment. This paradigm shift holds promise for improved model performance and robustness, particularly in domains like healthcare where data variability is high.

Work description

This project focuses on developing and evaluating TTA techniques to improve model performance under distribution shifts. The core objective is to enable pre-trained models, to adapt dynamically to new, unseen test data from different distributions without requiring additional labelled data.

Key tasks are:

1. **Literature Review**: research existing approaches to distribution shift and test-time adaptation, particularly in medical imaging.
2. **Algorithm Development:** develop and implement TTA methods that enable existing pre-trained backbones to adjust to test-time data.
3. **Model training and testing:** train models on source domain data and evaluate their baseline performance on shifted target domains (for this task we plan to use public datasets such as MedMnist).
4. **Performance Evaluation:** i) conduct quantitative and qualitative assessments to measure how well the TTA-augmented models generalize to new data; ii) compare against traditional supervised learning approaches to highlight the improvements in generalization.
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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