Degree project 30 credits in Biomedical Engineering

Whole-body virtual scanning

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

Image-to-image translation is a technique that transforms images from one domain to another, offering significant potential in the medical field for creating a Digital Twin—a virtual replica of a patient. This approach aims to generate accurate images across multiple modalities, thereby reducing the need for multiple scans and minimizing radiation exposure. In medical imaging, the goal is to develop a virtual scanner capable of producing faithful, multi-modal images, helping diagnostic processes and improving patient safety. Current research in medical image-to-image translation has primarily focused on translating between specific modalities, such as MRI-to-CT or PET-to-CT, with promising results. However, most of these efforts are limited to specific anatomical regions, such as the head or chest, and do not address the more complex task of whole-body image translation. Developing methods for whole-body image translation introduces challenges due to the reduced amount of available data and higher computational cost, thus making model training more difficult and resource-intensive. Nonetheless, investigating whole-body image-to-image translation represents a significant step forward in creating a fully functional virtual scanner, advancing the capabilities of medical diagnostics and reducing patient risk.

Aim of the project

This project aims to develop a whole-body virtual scanner through image-to-image translation techniques based on Generative Adversarial Networks or diffusion models. By focusing on full-body medical image translation across multiple modalities, the project seeks to create an accurate and efficient Digital Twin of a patient, reducing the need for multiple scans, minimizing radiation exposure, and improving diagnostic precision.

Work description

This project will focus on developing a **whole-body virtual scanner** using advanced image-to-image translation techniques. The key objectives and tasks for this project include:

1. **Literature review:** research existing approaches in medical image-to-image translation, focusing on full-body imaging and cross-modality applications, starting from a selection of already reviewed papers. This task will inform the project's direction and guide the development of the next tasks.
2. **Data Preprocessing:** This task involves cleaning, segmenting, and aligning the data to ensure consistency across modalities. We plan to utilize a publicly available whole-body PET-CT dataset, comprising approximately 1,000 patients. Preprocessing will be facilitated by ongoing research and existing scripts associated with this dataset.
3. **Model Development:** Implement the image-to-image translation framework, leveraging existing architectures like GANs or diffusion models, and adapting them to handle the challenges of full-body medical imaging, as identified in task 1.
4. **Algorithm Optimization:** Fine-tune the image translation algorithm to enhance accuracy in cross-modality image generation while maintaining anatomical detail. Novel techniques will be explored to reduce computational complexity and improve efficiency during training.
5. **Validation and Testing**: Assess the virtual scanner's performance using held-out data from the original dataset (Task 2) through both quantitative metrics and qualitative evaluation. For the qualitative assessment, we may involve radiologists collaborating with our team to provide expert visual inspections.
6. **Reporting and Documentation:** document all the 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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