Lehrstuhl für Bildverarbeitung

RWTH AACHEN UNIVERSITY

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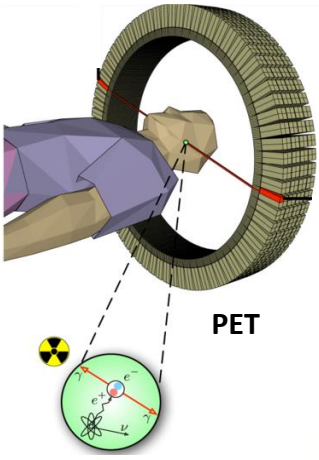
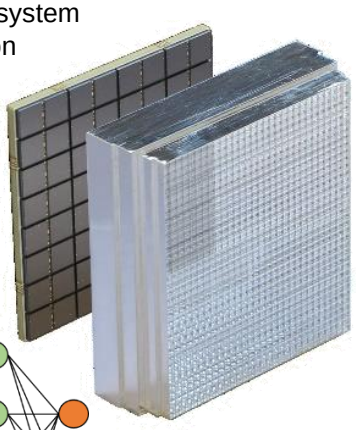
Bachelor's / Master's Thesis

PET Detector Timing Calibration



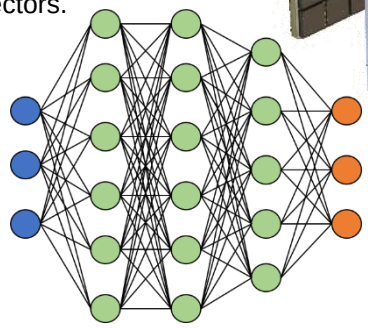
Background

Positron Emission Tomography (PET) is a vital imaging technique in oncology and neurology. Traditionally, PET scanners are combined with CT scanners for joint imaging. However, the integration of PET with Magnetic Resonance Imaging (MRI) represents a cutting-edge advancement, offering superior imaging capabilities.In collaboration with the Uniklinik RWTH Aachen and our spin-off company, our team is actively engaged in developing demonstrators and fully functional PET and PET/MRI systems. At the core of these systems lies the PET detector. This detector captures flashes of optical photons generated by scintillators upon gamma-ray interaction. These flashes are then registered by photosensors, producing digitized data from multiple channels, each containing timestamp and energy information. The goal is to accurately determine the gamma photon's time of interaction and deposited energy from these individual "hits". Recently, machine learning approaches have demonstrated significant promise, offering improved accuracy and scalability compared to classical methods by effectively handling complex, high-dimensional data. In our group, we have successfully developed a supervised machine-learning-based timing calibration technique that has yielded outstanding results for a pair of detectors in a bench-top setup [1] [2]. This thesis project will build on our existing work by exploring machine learning methods for calibrating a larger PET system comprising multiple detectors. The objective is to develop and validate scalable calibration approaches, contributing to the advancement of hybrid PET/MRI technology.



Tasks

- Develop, on already gathered calibration data, a detector-individual timestamp calculation model by analyzing the timing data from individual photosensor channels and applying advanced algorithms to improve timing resolution and accuracy.
- Translate the concept to PET system consisting of multiple detectors.



Your Profile

- Interest and experience in data analysis and machine-learning
- Programming skills (Python; C/C++ of benefit)

Our Offer

This thesis offers insights into PET detectors and systems. Calibration data and previous methods can be provided as a foundation. In addition to the basics of the various medical imaging methods, our mixed team of physicists and engineers offers many years of experience in academic and industrial research.

[1] Mueller, Florian, et al. "A semi-monolithic detector providing intrinsic DOI-encoding and sub-200 ps CRT TOF-capabilities for clinical PET applications." *Medical Physics* 49.12 (2022): 7469-7488.

[2] Naunheim, Stephan, et al. "Improving the timing resolution of positron emission tomography detectors using boosted learning—a residual physics approach." *IEEE Transactions on Neural Networks and Learning Systems* (2023).