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Simulation and Image Reconstruction for a Low-Cost PET Detector Concept

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A simulation of a low-cost PET detector concept is presented. The model is used to evaluate the imaging potential of the proposed detector, to optimise image reconstruction techniques for this design, and to feed back performance metrics to the detector design process.

The PET system was developed with GATE (Geant4 Application for Tomographic Emission), incorporating a detector layout based on modular scintillators and SiPM arrays. Simulation-based and analytic models of module and channel occupancies are used to assess the feasibility of signal multiplexing to reduce data acquisition electronic costs.

Reconstruction of simulated data is performed using both Filtered Back Projection (FBP) and Maximum Likelihood Expectation Maximisation (MLEM). The performance of these classical algorithms is compared for the low-cost detector concept, with and without integration of time-of-flight (TOF) and depth-of-interaction (DOI) information. Due to the reduced system size and sparse detector layout, TOF and DOI have limited impact, and this comparative study aims to demonstrate that high-quality, clinically usable images can still be obtained despite these constraints.

Benchmark studies using realistic brain phantoms are used to compare image quality from the low-cost system with that of a standard full-ring commercial PET scanner. These studies aim to establish the viability of simplified PET detector designs in producing clinically relevant imaging, contributing to more accessible diagnostic tools in low-resource settings.

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