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3D In-System Calibration of PET Detectors

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In PET science, numerous high-performance detector designs are being investigated that are slowed in their system integration, e.g., due to a complex positioning calibration, including depth-of-interaction (DOI), required for several light-sharing designs. This process usually happens in benchtop setups, but a prerequisite for system integration is the fast acquisition of the training data for machine-learning applications and a practicable re-calibration and quality control.

We propose a new 3D in-system calibration with data acquisition inside the scanner by software-collimating a radioactive point source combined with angular detector irradiation for DOI. Experiments were conducted with a point source mounted to a 3-axis motor and placed inside a scanner dummy (120 mm diameter). The source was moved in front of a slab detector ($(24 \times 10 \times 1)$ mm³ slabs). By selecting orthogonally incident gamma rays, a planar calibration was conducted using Gradient Tree Boosting. Then, the DOI was calibrated by selecting oblique angles and calculating the DOI label from the geometric ray path and the planar position estimate.

For planar positioning, the results were within 1% of state-of-the-art calibration at 0.8 mm MAE and 1.19 mm FWHM. For DOI, 1.13 mm MAE and 2.47 mm FWHM were achieved. The method's applicability to different scanner geometries was analytically calculated and investigated.

The proposed in-system calibration method is suitable for 3D-calibrating assembled PET systems.

Field

Systems and applications

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