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3D position estimation in monolithic scintillation cameras using B-spline response parametrization.

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Scintillation camera is a position sensitive scintillation detector widely used in medical imaging. The use of monolithic unsegmented crystals was for a long time limited to scintigraphy and SPECT applications, while in PET scanners highly segmented detectors were used. Since recently, the possibility of employing relatively large monolithic scintillators in PET is being also considered. On the other hand, there is a growing interest in replacing the traditionally used center-of-gravity positioning with statistical reconstruction methods such as least squares (LS) or maximum likelihood (ML) which offer, among other advantages, lower distortion near the crystal edges, especially important in the case of compact detectors.

Implementation of statistical event positioning in many cases benefits from parameterization of the photodetector response as a function of coordinates. It was suggested in the literature that using splines for parametrization provides a good compromise between the memory requirements and flexibility. Additional advantages include fast estimation (only arithmetical operations are required) and simple control over regularization.

We developed a library for 2D and 3D B-spline parameterization with the following features:

- fully automatic fit of the spline to 2D and 3D data using cross-validation to optimize the knot number;
- possibility to take into account symmetry of the photosensor response;
- effective dimensionality reduction from 3D to 2D in special cases;
- grouping photosensors with common response function within a group when allowed by the detector geometry.

Here we present our results on B-spline response parametrization (2D and 3D) for several types of the response symmetry. The parametrization technique was successfully applied for 3D positioning performed at graphical processing unit (GPU) hardware using contracting grid search with ML and LS methods with the data obtained through Monte Carlo simulations as well as with those acquired with a scintillation camera. The library is implemented as a part of an open source data processing package ANTS2.

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