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Contribution - Deep Learning for Predicting Gamma-Ray Interaction Positions in LYSO Detector

DS applications and challenges in Medicine, Natural Sciences, and Engineering

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Abstract

Introduction

Organoids, stem-cell-derived three-dimensional tissue cultures, find increasing applications ranging from disease modeling to drug discovery and personalized medicine. These growing numbers of uses lead to strong demand for novel measurement capabilities.

In this abstract, we present the first steps of developing an on-chip PET system capable of imaging organoids. We evaluate the prediction of gamma-ray interaction positions with deep learning methods trained on simulated data.

Materials & Methods

For this purpose, we designed a Geant4 based Monte Carlo simulation of a tentative detection block consisting of three continuous LYSO crystals with silicon photomultipliers (SiPMs) added to multiple sides of the detector. We created a large dataset of light pattern images of a wide range of gamma-ray incidence positions and angles with the simulation. The dataset is used to train a Convolutional Neural Network (CNN) based reconstruction network learning the nonlinear relationship between gamma-ray interaction positions and their resulting surface light patterns. We also established a centroiding based baseline method for comparison with the deep learning based approach.

Results

We determined the optimal number of surfaces covered with SiPMs needed to predict the interaction position with various experiment runs. The experiments showed that some surfaces encode significantly more information compared to others. The best network achieved a mean average error (MAE) of 1.48 mm when trained on a dataset of 110,000 samples and tested on 14,000 samples. The baseline method achieves a MAE of 6.16 mm on the same test set.

Summary

The results indicate a promising direction for deep learning based gamma-ray interaction position prediction for a detector block of continuous crystals. With a larger dataset and an extensive hyperparameter search, the results will be further improved. In successive experiments, we will compare the results achieved with simulated data to experimental data.