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Advancing Neural Network Training Datasets for Mobile Radioisotope Detection

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The automatic detection and identification of gamma-ray spectra are essential for the deployment of radioactive threat detection networks in urban environments. The Sigma dataset, comprising 1.5 billion gamma-ray spectra collected across London, highlights the necessity of automated systems, such as convolutional neural networks (CNNs), to efficiently analyse vast amounts of spectral data and detect potential threats in real time. However, training such models requires realistic threat spectra, including those from moving sources, which presents an opportunity for further research.

This work details the development of a framework that integrates Geant4 simulations with laboratory experiments, enabling the generation of spectra from moving radioactive sources. A custom-built pulley system was used to move sources at controlled speeds, ranging from 1 to 5 cm/s, through the field of view of a sodium iodide (NaI) detector. Initial studies were conducted on static sources, ^{137}Cs and ^{60}Co, to refine the simulation model. The laboratory setup for the moving source was then comprehensively modelled in Geant4.

The resulting spectra from the moving source demonstrated strong agreement between experimental and simulated data across different speeds and distances. Simulated spectra were then combined with Sigma background data and tested within a Sigma-trained CNN, with strong results reported even at the extremes of the detector field of view. These simulations provide a crucial step toward training CNN-based detection systems for real-world deployment.

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