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Machine Learning-based Gamma Spectroscopy with Multi-Spectral Tracking

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This project entails the development of a machine learning-based gamma detection system with tracking and prediction capabilities. It involves integrating gamma spectroscopy via an artificial intelligence model, including a custom neural network trained on spectra from various isotopes and a compact detector. The model would be integrated into a compact, low-cost, micro-controller enabled system with additional sensors to provide the hardware. This includes, but is not limited to, a thermal sensor, GPS sensor, multi-spectral camera, etc. and would be used to run and manage the model. The overall system with the neural network and multi-spectral system would be designed to provide a useful and inexpensive complement to current radiation safety methods and additionally serve as an early warning system (e.g. in the case of radiation leaks). Additionally, the treatment of noise in the obtained spectra, both environmental and systematic, will be investigated in this research via neural networks and Kalman filters. This is crucial for monitoring out in the field, where low-level monitoring often suffers from background interference. The value is increased by the packaging of thermal and GPS sensors, together with a standard camera and infrared camera for mobile object detection, complementing the gamma-ray spectra identification.

Thermal sensors combined with an infrared camera can allow the detection of heat signatures, which is useful for finding the source of emissions. Through the use of recursive algorithms, an interactive multiple-model estimator could offer prediction capabilities through modelling trajectories of gamma radiation within the environment. Eventually, a self-correcting system with identification and tracking can be used to provide early warning or other useful information regarding radiation in the environment. Although a stationary system with stationary sources will be tested, one could easily apply this to a dynamic mobile system (e.g. drones and surveillance cameras) with the addition of motors or compact vehicles for transportation. This system could be compared to existing radiation safety methods and warning systems, as well as machine learning benchmarks for spectra prediction. For example, one could test how well it identifies radiation leaks, the number of false positives, and the accuracy of the tracking system.

It is also believed that the supervised training process of the network can include examples of noise, to assist in obtaining as clean a spectrum as possible, and to guide the network to the true reaction data.
Ideally, the network will learn to identify the isotopes by peaks and possibly backscatter patterns. This will prevent the inclusion of unanticipated sources confusing the network when making predictions.

The consideration of radiation monitoring environments, such as nuclear waste disposal sites and nuclear power plants (e.g. Koeberg), yields insights to the value of this research. A low-cost, efficient radiation monitoring device could assist in radiation protection cases, capable of detecting gamma emissions and hotspots in the surrounding environment. There is also the use in the field, for remote monitoring and built-in GPS for local-

ization. Moreover, a mobile system can be used to investigate stationary and moving
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sources in the field (e.g. geological vaults), providing information regarding the ener-
gies and intensities of various gamma sources. There is also the knowledge gained by investigating further development of micro-
controller-enabled systems with deep learning-based object recognition and tracking
software. There is a direct comparison to be made with existing surveillance and monitoring technology.

Apply to be considered for a student ; award (Yes / No)?

Yes

Level for award;(Hons, MSc, PhD, N/A)?

PhD

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