Development of a Deep Learning-Based Model for Radionuclide Identification

Sang Yun Lee,[1] Chae Hyun Lee,[1] , Han Young Joo,[1] and Joo Hyun Moon[1*]

[1] Department of Energy Engineering, Dankook University,
119, Dandae-ro, Dongnam-gu, Cheonan, Chungnam 31116, Republic of Korea

* *e-mail: jhmoon86@dankook.ac.kr*

In the event of a radiological release due to a nuclear power plant accident, rapid and accurate determination of radionuclide concentrations is essential to assess environmental contamination and radiation dose rates. Such assessments serve as critical data for evacuation planning and decontamination efforts, particularly during the early stages of an incident, where effective response can minimize casualties.

Traditionally, radionuclide identification relies on gamma-ray spectrum analysis, which is time-intensive and often inaccurate for complex spectra involving multiple radionuclides with similar energy peaks. To address these challenges, this study introduces a deep learning-based radionuclide identification model using a Convolutional Neural Network (CNN). By analyzing gamma-ray spectra, the model effectively distinguishes radionuclides with overlapping energy peaks, outperforming conventional methods in speed and accuracy.

Key radionuclides, including Cs-134, Cs-136, Cs-137, I-131, and others identified in the Fukushima Daiichi nuclear disaster, were used for training. Synthetic gamma-ray spectra, incorporating noise and background radiation, were generated to simulate real accident conditions. The CNN model, designed with a 1D architecture, includes convolutional, max pooling, batch normalization, and dense layers to extract key features and minimize overfitting.

Performance evaluation using metrics such as Jaccard Score, Hamming Loss, and Classification Report demonstrated the model's high accuracy in multi-label classification. The model achieved a Jaccard Score of 0.742 and an AUC of 0.8968, indicating robust radionuclide identification capability. These results confirm the effectiveness of the proposed deep learning approach for rapid and precise radionuclide identification in nuclear emergency scenarios.