Studi klasifikasi multikelas radionuklida berbasis CNN 1D dan 2D dengan Metode Adversarial Learning = A Study of multiclass radionuclide classification based on 1D and 2D CNN using Adversarial Learning Methods

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Abstrak

Identifikasi radionuklida berguna untuk keamanan nuklir, monitor lingkungan, serta diagnosa kesehatan, di mana keandalan identifikasi radionuklida di berbagai kondisi merupakan hal yang penting. Data spektrum gamma biasanya rentan terhadap gangguan noise. Penelitian ini menyelidiki performa machine learning dalam mengenali radionuklida di bawah pengaruh gangguan adversarial attack, yang dirancang untuk melatih ketangguhannya terhadap gangguan luar. Pada penelitian ini, digunakan data spektrum gamma dari Co-60, Cs-134, dan Cs-137 yang di-preprocessing dengan background subtraction, adversarial attack, dan logarithmic normalization, kemudian lebih lanjut dengan zero padding dan 2D mapping dengan Hilbert curve. Data ini digunakan untuk training model Convolutional Neural Network (CNN). Terdapat 4 model yang dibuat: model 1D, model 1D dengan adversarial attack, model 2D, dan model 2D dengan adversarial attack. Model 1D dan 2D menunjukkan akurasi yang tinggi (98% untuk keduanya) dengan konvergensi loss yang cepat saat training. Dengan adversarial attack, proses training dan identifikasi radionuklida menunjukkan performa yang lebih buruk, yakni 77% untuk model 1D dan 71% untuk model 2D. Ini menunjukkan bahwa mentode adversarial learning menggunakan adversarial attack cenderung menurunkan performa model terhadap noise yang tak kasat mata, dan model tidak dapat memiliki performa yang lebih baik maupun sebaik model tanpa adversarial attack.

.....Radionuclide identification finds its use in nuclear safety, environmental monitoring, and health diagnosis, where identification performance under noisy conditions is of utmost importance. Gamma-ray spectrum data are typically vulnerable against external noise. This research investigates the performance of machine learning in identifying radionuclides under the influence of adversarial attacks, which are designed to train the robustness of the model against external perturbations. In this research, the gamma-ray spectrum data of Co-60, Cs-134, and Cs-137 are preprocessed with background subtraction, adversarial attack, and logarithmic normalization, and additionally with zero padding and 2D mapping using the Hilbert curve. The data is then used to train the Convolutional Neural Network (CNN) model. Four models are constructed: the 1D model, the 1D model with adversarial attack, the 2D model, and the 2D model with adversarial attack. The 1D model and the 2D model exhibits high accuracy (98% for both) with fast loss convergence during the training process. With the adversarial attack, the training and radionuclide identification decline in performance, with 77% accuracy for the 1D model and 71% for the 2D model. This demonstrates how adversarial attaqcks can decrease the model’s robustness against external perturbations, and that the models’ performances are significantly worse compared to those without the adversarial attacks.