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Interpretable neural network for airborne alpha radioactivity monitoring in decommissioning sites conditions.

On nuclear sites, such as nuclear power plants, instruments for measuring atmospheric radioactivity are deployed to ensure the radiation protection of workers. This type of instrument continuously samples ambient air aerosols on a filter, measures as an energy spectrum the radioactivity accumulated on the filter in real time, and shall notify the operator if transuranic alpha emitters are detected. In the specific case of nuclear facilities dismantling, sudden variations in aerosol ambiance, both in terms of size distribution and concentration, lead to a deterioration of the nuclear measurement, and often to a false alarm.

In this work, we first developped a nuclear code to generate semi-synthetic training data. We then constructed a deep learning algorithm that accurately detect the presence, or absence, of artificial alpha emitters based on the knowledge of the raw nuclear measurement, even in atypical atmospheric conditions.

The "black-box"aspect of decision-making of neural networks in an issue as sensitive as nuclear safety represents a major obstacle to the use of these techniques in practice. Therefore, we first implement a tool to visualize the classification process of the model (explainability). Moreover, theoretical guaranties can be imposed on the model for better interpretability, even though it can lead to the deterioration of pure performances. In particular, a partially isotonic neural network is developed to integrate prior physical knowledge on the problem. Forecasts are also calibrated to match an interpretable probability. Lastly, an uncertainty analysis of the model output is performed taking into account the different sources of uncertainties.

Special/ Invited session

Explainability_FR

Classification

Both methodology and application

Keywords

AI, interpretability, radioactivity

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