A multi-window neural-network model for line-profile-based temperature estimation in low-temperature plasma optical emission diagnostics

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Optical emission spectroscopy is widely used for plasma diagnostics, but profile-based temperature estimation remains sensitive to line selection, instrumental broadening [1], noise, baseline distortions and overlapping spectral features. In this work, a multi-window artificial neural-network architecture is developed for spectrum-level temperature estimation from emission spectra of high-frequency electrodeless discharge lamps (HFEDL). The target temperature is defined as a gas-temperature-related line-profile parameter associated with the Doppler broadening of emission lines.

The model was trained, validated and tested on a controlled synthetic dataset with known ground-truth temperature values. Its performance was evaluated using MAE, RMSE, R^2, exact temperature-class accuracy and neighboring-class accuracy. The proposed multi-window approach was compared with single-window CNN, full-spectrum resampled CNN and feature-based Random Forest/Extra Trees baselines. The attention-based variant also provides information on the relative contribution of individual spectral windows, supporting model interpretability in line with recent developments in machine-learning-assisted optical emission diagnostics [2].

The developed software prototype integrates spectral-window extraction, neural-network training, validation, testing, inference and visualization. The results demonstrate the feasibility of a TRL4-level AI-supported diagnostic model for line-profile-based temperature estimation under controlled laboratory conditions, providing a basis for further comparison with classical profile-fitting methods and experimental HFEDL spectra.

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