

Empowering Optical Diagnostics with Image-Based Spectral Analysis via Multi-Objective Supervised Learning

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Abstract

Optical diagnostic methods have been pivotal in characterizing plasma across both basic science and industrial applications. As artificial intelligence becomes increasingly integrated into plasma research, the quality of plasma data obtained via reliable measurements becomes ever more important. Despite these advancements, spectral data analysis remains a significant challenge in plasma studies for both experts and novices due to its complexity and reliance on one's experience and intuition. Moreover, deconvolution—a critical step in fitting spectra and extracting their parameters—has not yet achieved full automation. In this work, we demonstrate the application of a supervised learning-based deep neural network to extract plasma information from spectrum images, bypassing curve fitting. Utilizing a 2D-ResNet architecture, our model was trained on synthetic spectrum images designed for broadband ultraviolet-visible absorption spectroscopy, specifically targeting ozone–nitrogen oxides mixtures in air plasmas. Our results show the remarkable capability of image-based spectral analysis, which can accurately capture both peaks and trends of experimental graphs. This pioneering application of AI will offer promising alternatives to conventional approaches.

Keywords: Optical emission spectroscopy, Plasma, Data analysis, Supervised learning

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Education History

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Professional Background

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2019 – 2022	Senior Researcher, Korea Institute of Fusion Energy (KFE)
2017 – 2019	Postdoctoral Fellow / Research Assistant Professor, KAIST
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Selected Awards and Honors

1. 2024 Technology Innovation Awards of College of Engineering, KAIST
2. 2024 Best Research Team Award, KVS
3. 2022 Best Paper Award (Emerging Scientist), Korea Institute of Fusion Energy (KFE)
4. 2021 Young Researcher Award (U40), AAPPS-DPP
5. 2018 Emerging Scientist Award (Plasma Physics), Korean Physical Society



Selected Publications

1. Stabilization of liquid instabilities with ionized gas jets, Nature 592, 49–53 (2021)
2. The creation of electric wind due to the electrohydrodynamic force, Nature Communications 9, 371 (2018)
3. Interplay among ozone and nitrogen oxides in air plasmas: Rapid change in plasma chemistry, Chemical Engineering Journal 352, 1014–1021 (2018)
4. Electron characterization in weakly ionized collisional plasmas: from principles to techniques, Advances in Physics: X 4, 1526114 (2019)
5. Plasma-functionalized solution: A potent antimicrobial agent for biomedical applications from antibacterial therapeutics to biomaterial surface engineering, ACS applied materials & interfaces 9, 43470-43477 (2017)