Contribution ID: **35**   Type: **not specified**

Application of Deep Learning to Reflectometry Signals in Nuclear Fusion Plasmas

Tuesday 28 January 2025 13:54 (12 minutes)

In a context where the transition to sustainable energy is crucial, nuclear fusion appears as a promising solution, capable of generating a lot of energy in a clean and sustainable way. One of the main challenges of nuclear fusion in tokamaks is controlling the shape and position of the plasma, allowing the optimization of the process and preventing the plasma from touching the walls, degrading the reactor and losing confinement and energy, making fusion impossible.

Microwave reflectometry is a diagnostic tool that allows monitoring the position of the plasma by analyzing the reflection of electromagnetic waves in the plasma. From the beat frequency spectrogram, the group delay curve is obtained and, through Abel inversion, the electronic density profile. However, system noise, plasma dynamics and reflectometer characteristics can affect group delay curves, introducing errors into the extracted profiles, making it essential to develop more reliable methods for group delay curve extraction.

Recent advances have demonstrated the effectiveness of Convolutional Neural Networks and Transformers in analyzing spectrograms, both for signal classification and for data denoise and reconstruction. Therefore,this work proposes the application of these deep learning models to obtain more reliable group delay curves, consequently, more representative density profiles, improving plasma control and supporting the general objective of making nuclear fusion more viable.

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