

Leveraging neural networks for real-time plasma density inference using beam emission spectroscopy

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Beam emission spectroscopy [1] (BES) is an active plasma diagnostic employed for plasma density measurements. In multiple BES applications such as synthetic diagnostics, density inference models, and plasma control frameworks computationally expensive emission inference calculations are utilised to determine the expected emission for a given density profile. The resource intensiveness of such calculations limits the applicability of BES for real-time measurements and control, while also restricting the speed of synthetic diagnostics.

In this work, we present two possible solutions to this problem in the form of a neural networks that can predict beam emission relevant profiles on a sub-millisecond timescale, both of which explore the use of extreme learning machine, multi-layer perceptron and convolution neural networks with scalable physics informed loss functions [2].

A forward inference model was developed focusing on emission inference along the beam based on assumed along the beam density profiles in an effort to be integrated and speed-up forward modelling based density inference frameworks, such as IDA [3]. The framework aims to enable real-time density measurement features, developed for the ASDEX-Upgrade Li-BES system [4].

A reverse inference model was developed focusing on plasma density inference along the beam based on beam emission measurements in order to enhance existing plasma density reconstruction methods used on the W7X stellerators Alkali-BES system [5].

Following preliminary results, inference uncertainty was assessed by use of multiple networks and found to be within acceptable margins, inference smoothness was deemed comparable to that of numerical methods and network performance was not affected by BES specific spatial resolutions.

References:

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