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Neural Network Surrogate for Acceleration of Gyrokinetic Codes

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Previous work [1,2] has successfully applied neural network (QLKNN) surrogates for the quasi-linear gyrokinetic simulation code QuaLiKiz [3] to predict core tokamak transport heat and particle fluxes, resulting in 3-5 orders of magnitude reduction in computation time with minimal (up to 10%, case dependent) loss of precision. The current study aims to apply this concept using the gyrokinetic simulation code GKW which includes electromagnetic fluctuations, important in high performance regimes, and realistically shaped equilibria required to more accurately model the edge region where transport barriers develop. However, this model will be trained on the growth rates as opposed to the fluxes which will allow the development of novel quasi-linear saturation models with the aim of improving the performance of existing quasi-linear codes.
As part of the FASTER project, we will first develop a proof of concept neural network (NN) trained to predict instability growth rates using existing QuaLiKiz datasets converted to ITER Integrated Modelling and Analysis Suite (IMAS) standards for this purpose. This allows the creation of a pipeline to train a NN that accepts IMAS standardised inputs, important for later use with GKW. It also enables the use of QuaLiKiz inputs to build the pipeline allowing faster testing and validation that using GKW simulations.
This will be then be repeated using a newly generated GKW dataset based on the JET experimental domain which will in turn be used to test quasi-linear models. Using GKW comes at the downside of heavily increased computation times which for linear simulations ranges from 1-100h as opposed to an average of 8s for a standard QuaLiKiz wavevector scan. The goal of the neural network is therefore to produce results qualitatively similar to GKW simulations in a similar timeframe as QLKNN. This would effectively reduce the simulation time by up to 8 orders of magnitude while increasing the precision of predictions relative to experimental results.
We present the first two major milestones of this study: the development of software to convert QLK simulation data to and from IMAS IDS files, and the preliminary results of the NN surrogate for QuaLiKiz calculating the growth rates and frequencies of the most unstable modes.

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