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FASTER : IA methods for fast and accurate turbulent transport prediction in tokamaks

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Accurate simulation of fusion plasma turbulence is required for reactor operation and control, but is either too slow or lacks accuracy with present techniques.
The FASTER project aims to circumvent these conflicting constraints of accuracy and tractability and provide real-time capable turbulent transport models with increased physics fidelity for tokamak temperature, density, and rotation velocity prediction through usage of machine learning techniques.
In recent years, a new type of neural network(NN) based quasilinear turbulent transport model has been developed for the simulation of fusion plasmas, giving increasingly promising and fast results and allowing their use in integrated simulations[1,2]. These surrogate models are obtained by training NNs on large datasets of simulations generated with reduced quasi-linear codes like QuaLikiz[3] or TGLF[4]. While extremely powerful, this technique limits the accuracy of the surrogate model to that of the original one.
One way to further improve the capabilities of NNs based quasi-linear models is to train them on datasets generated with higher fidelity codes. For instance, the linear response of state-of-the-art gyrokinetic flux tube codes such as GKW[5] or GENE[6] could be used. Thanks to the growth of HPC resources, the generation of a dataset of a few million linear gyrokinetic simulations is now within the reach of a single research group. The size of the dataset can be further increased by mobilizing the community and collecting gyrokinetic simulations performed worldwide. To this end, we have extended the IMAS data model to include a unified standard for the inputs and outputs of gyrokinetic simulations. This standard is used to store gyrokinetic simulation results from different codes in a common database: the GyroKinetic DataBase (GKDB).
The GKDB is designed to be a repository of open source simulation data, a platform for code benchmarking, and a springboard for the development of fast and accurate turbulent transport models. The project is hosted and documented on GitLab (https://gitlab.com/gkdb/).
Thanks to the unified data model used for the database, quasilinear as well as linear and nonlinear simulations can be stored sharing compatible inputs and output. This offers the possibility to build fast quasi-linear models by training neural networks on the linear simulation data and to test their robustness against the non-linear simulation data. Moreover, code comparison is always challenging due to the different normalizations and conventions used. The IMAS “gyrokinetics” standard greatly facilitates the benchmarking of codes (δf flux tube gyrokinetic simulations and/or quasilinear models) against each other.
We will give an overview of the FASTER project and presents some proof of concepts of database usage including data access and visualization.
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