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Fast surrogate models for power and particle exhaust in fusion

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Accurate simulations of the scrape-off layer plasma in a tokamak employing state-of-the-art numerical models (e.g. SOLPS-ITER) require long convergence times. Such physically sophisticated models are required for a detailed design e.g. of the divertor in DEMO or in a fusion power plant (FPP). For design scoping studies or integration of models with the core-plasma, currently used reduced fidelity models lack either accuracy or capabilities. Other applications include control specific needs w.r.t. fast model based predictors for the level of plasma detachment in the divertor. All this warrants the development of surrogate models, which interpolate between existing simulations, to allow for fast and accurate results in the whole parameter space. We created a neural network model by training on a database of reduced fidelity fluid neutral SOLPS-ITER simulations. This database includes a cross-machine size scaling, making the developed model applicable to many devices and scenarios. The neural network model is capable of computing the electron temperature in the whole 2D SOL and divertor domain for different physical regimes in less than a second. The deviations between the neural network model and the original simulations are less than 10 percent for the majority of cases. The model is compared to high-fidelity SOLPS-ITER simulations from the ITER IMAS database. Two approaches are tested to reduce the deviations between the model and the ITER simulations: Scaling of the gas-puff parameters and transfer learning. While both reduce the deviations only transfer learning allows for predicting full 2D plasma profiles on the ITER geometry. Some applications for such a model are showcased.

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