Development and validation of NEUPED, a neural-network based regression of the EPED1 first-principles pedestal model*

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A highly efficient numerical tool for predicting the pedestal height and width for tokamaks capable of real time application during H-mode operations has been developed. The new tool, named NEUPED, is constructed from a regularized non-linear regression of EPED1 simulations. The regression is performed with a multilayer neural-network. A single neural-network is trained to capture the EPED1 predictions across an input parameter range that spans multiple devices. The multi-device database of EPED1 runs that has been used for training the neural-network was generated by leveraging High Performance Computing capabilities enabled by the AToM project. To date the database comprises more than 18000 EPED1 predictions using inputs from the parameter space characteristic of DIII-D (3000 cases), KSTAR (700 cases), JET (200 cases) and ITER (15000 cases). At strong plasma shaping, the density dependence of the pedestal becomes stronger, and above a critical density the EPED1 model predicts that the stable solution can bifurcate into two branches: H-mode and Super H-Mode. In NEUPED, this physics is captured by training the NN to reproduce the pedestal height and width of both branches. When only one solution exists, the solutions of the two branches are set to be equal. Handling of the EPED1 results database and training of the neural network is performed within the OMFIT framework. The trained neural network can be used both within OMFIT, and as a portable standalone code. Because NEUPED is millions of times faster than running EPED1 directly, and provides a good approximation to EPED1 predictions, it enables numerous applications, including incorporation in control algorithms and highly efficient integrated transport simulations.

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