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A deep learning-based prediction for the multi-scale instability in fusion plasma

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Automated learning from data by means of deep learning is finding use in an ever-increasing number of applications. Physicists, has already recognized the need for the modelling of machine-learning systems [1, 2]. Plasmas and plasma-enabled technologies are pervasive in everyday life, but their nonlinear, multiscale behavior poses severe challenges for understanding, modeling, and controlling these systems. However, due to their computational demands a realistic description of system size and timescales remains challenging for many problems. With the emergence of the machine learning (ML) algorithms, this changed, especially in fluid mechanics. In this report, we provide a deep learning-based model with the prediction of multi-scale instability in real time.

Thanks to recent development ML algorithm, we exploit a surrogate transport model. The databases are built based on the simulation results using the ExFC and MHD @ Dalian Code (MD code). The ExFC is a fluid-type transport code based on the Landau-fluid model extending to study tokamak plasma multi-mode multi-scale turbulence dynamics. And the MD code is an initial value code including the nonlinear evolution of the NTM. Therefore, the newly constructed surrogate transport model shows the sufficient ability to reproduce the same simulation results. Furthermore, the newly ML model can accurately obtain the physical characteristics of tokamak MHD and micro-instability at a computational cost of only a small amount of CPU time.

We exploit a surrogate transport model, namely ExFC-NN [3, 4]. The databases are built based on the simulation results using the ExFC. The schematic diagram for the construction is shown in Fig. 1. Therefore, the newly constructed surrogate transport model shows the sufficient ability to reproduce the same simulation results. Furthermore, the ExFC-NN model can predict and speed up the analysis of the turbulence transport in tokamak experiments on the HL-2A. On the other hand, the newly ML model can accurately obtain the physical characteristics of tokamak MHD and micro-instability at a computational cost of only a small amount of CPU time.

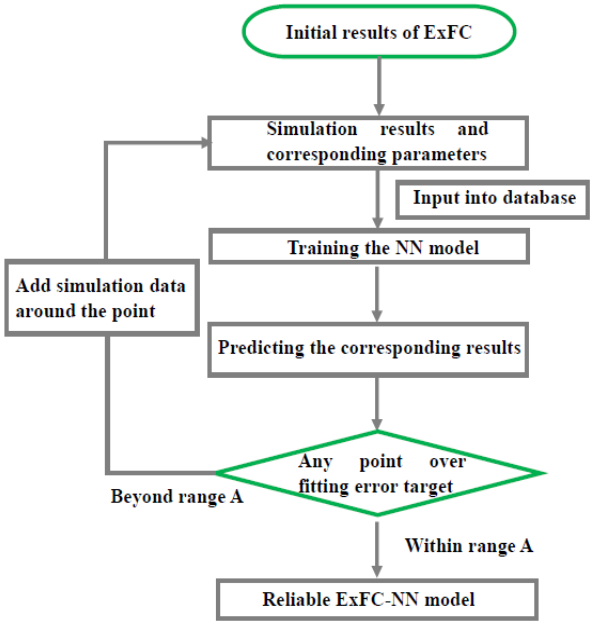

Fig. 1 Schematic diagram for the construction.

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