NEURAL NETWORKS APPLICATION FOR MODELING TRANSPORT PROCESSES IN PLASMA

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In modern plasma control systems, there is an increasing need for real-time modeling of physical processes. Such modeling can be used when, in loopback systems, it is desirable to use parameters for control, which are impossible or difficult to measure directly.

One of the options for applying real-time simulation is to replace the direct numerical solution of differential equations describing the physical process with the solution of a problem using neural networks. In this case, a slow, long process of the neural network training is performed in advance, and during application, the simulation result is quickly calculated with acceptable accuracy.

A typical example of such a physical problem is the control of a plasma disruption prevention system [1]. Such systems consist of a massive gas injection system or pellet injector and a disruption prediction module. By analyzing the discharge parameters in real time, the disruption prediction module generates a trigger signal with the required advanced time sufficient for triggering the injection system. Such a system is good for machines in which the duration of a plasma discharge is substantially less than the interval between shots and there is no significant neutron load on elements located close to the plasma. When discussing reactor scale machines, the task becomes more complicated: the requirements for the reliability of the system increase significantly and its elements should not be near the plasma all time.

The report considers the possibility of modeling the transport processes with the help of a neural network to control the position of the discharge quenching system. At the neural network training stage, it is necessary to prepare experimental data and perform modeling based on the numerical solution of the transport equations, which allows us to form a set of training examples. Training examples are used to configure the topology, the weighting matrix and the other parameters of the neural network. After training, the neural network becomes a nonlinear approximator of solutions of the transport equations and can be used to model them.

At the application stage, the current values ​​of the required measured plasma input parameters are passed to the input of the neural network. The network performs transport processes modeling faster than in real-time mode. At the output of the neural network, the predicted values ​​of the parameters necessary for the operation of the disruption prediction module are formed. Based on the obtained set of model data, the disruption prediction module generates a signal that the injection system should be moved closer to the plasma or farther from it, also based on the current plasma parameters, a signal is generated that the injection is started and the discharge is quenched.

References

1. J.A. Snipes et al., Nucl. Fusion, 2017, **57,** 125001