STUDY OF DISRUPTION PREDICTIONS IN TOKAMAK PLASMA USING COnvoluTIONAL NEURAL NETWORKS [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2023.50.2023.1.1.097

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The control of plasma discharge quenching is an urgent problem in research on controlled thermonuclear fusion. The need to predict the plasma disruption with a sufficient lead to launch systems for its prevention and/or mitigation was demonstrated in [1, 2]. The probability signal of disruption after a certain period of time must be formed during the entire discharge. The trigger to start the plasma disruption mitigation system is generated when the disruption probability exceeds the threshold value.

Massive gas injection systems with a movable valve have been developed, the activation of which requires a time of about 4 ms. This requires prediction of plasma disruption with a lead of at least 5 ms.

There are several methods for disruption prediction. Of the most commonly used, it is worth highlighting fuzzy logic, various types of neural networks, support vector machines, Bayesian algorithms. To calculate the disruption probability in fuzzy logic systems, there is a transition to linguistic variables that are processed using the base of production rules, and then a transition is made to the numerical value of the output variables.

In the case of using neural networks, the input signals are combined into a vector signal, the topology of the neural network is set, as a rule, representing a directed graph, and, based on training examples, weight coefficients are selected that connect the nodes of the graph.

In the support vector machine, the training data is mapped to an N-dimensional space, in which it is possible to divide the data into classes by a hyperplane, and the prediction problem is reduced to a classification problem.

The first preliminary step includes the selection of measured signals and calculated values, which will be used in real time to calculate the disruption probability after a given time [3, 4]. Initially, the tokamak signals available for real-time measurements and the calculated parameters are determined. Then a correlation analysis is performed in order to identify strongly correlated values and leave only one of them in the generated set.

To solve the problem of disruption prediction of a plasma discharge, a technique for using a convolutional neural network is proposed. Additionally, it becomes possible to use the disruption probability signal to control equipments position in order to protect it from thermal loads or ionizing radiation, as well as to generate readiness signals for other diagnostics and elements of the tokamak control system.

The work was supported by the State Atomic Energy Corporation Rosatom and the Ministry of Science and Higher Education of the Russian Federation within the framework of Federal Project 3 (U3), project No. FSEG-2023-0018 "Development and construction of jet and pellet injection systems of increased performance and resource".

References

1. Kapralov V.G. et al., Journal of Physics: Conf. Series, 2017, **907**, 1, 012010.
2. Dremin M M et al., Problems of Atomic Science and Tech., Ser. Th. Fusion, 2012 , **4**, 58.
3. Kapralov V.G. et al., Journal of Physics: Conf. Series, 2017, **907**, 1, 012027.
4. Gusev V.R. et. al., Proc of the 21st IAEA FEC. 2006, **16**, 21
1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/Mu/ru/CZ-Bogdanov.docx) [↑](#footnote-ref-1)