SYNTHETIC DATA PROCESSING FOR THERMAL POWER DIAGNOSTICS IN NEUTRAL BEAM LINES WITH NEURAL NETWORK APPLICATIONS [[1]](#footnote-1)\*)

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Kichik M.G., Dlougach E.D.

NRC "Kurchatov Institute", Moscow, kichik.mg@phystech.edu

The BTR (*Beam Transmission with Re-ionization*) code [1,2] is used for the design and analysis of neutral beam injection systems (NBI). Particularly, it was actively used in the design of the heating and diagnostic injectors for ITER [3-5]. BTR is intended to simulate the evolution of the neutral beam by tracing large number (several billions) of particles from the ion source to tokamak plasma. Thanks to the high performance and interactive interface, the BTR code operation looks and feels like a realistic NBI device simulator; it can be used for educational purposes as well. BTR is actively used to verify other NBI simulation models. BTR numerical capabilities and input/output data amount, including the geometry detailed representation, particle statistics, resolution of power deposition profiles, are flexibly adapted to various NBI design issues.

As the range of BTR application includes delivery of heat power loads at the injector elements and evaluation of different beam species contribution to the power load, the code can be efficiently applied to synthetic data generation, for the purpose of the load data analysis and classification by beam diagnostics and control systems. Synthetic heat load maps in NBI can be also used for the source beam parameters reconstruction and for NBI operation conditions control.

In this paper, Python machine learning tools [6,7] are applied to classify the power deposition loads in the NBI by their provenance. The implemented machine learning algorithm includes the following main steps: 1) data generation in the form of 2-dimensional numerical arrays using BTR code; 2) data labeling (classification of load type); 3) data preparation for training (filtering, standardization, normalization); 4) selection of loss function and quality criterion; 5) training of a neural network (NN) on the main data set; 6) evaluation of the model on a control data set. A comparative analysis of the performance and training quality for various types and NN architectures is given. The main ways of preventing overfitting are considered.

The accuracy of classifier predictions reaches 79% when training a linear model (LNN), and 86% when using the CNN architecture (convolutional neural network). Further improvement of the learning algorithms and the NN model optimization will allow our data processing system being applied to NBI synthetic diagnostics workflow, to maintain the beam line components safe operation control and beam ion source optimum tuning. ML based thermal data analysis can be effective for injector geometry optimizations, and for real-time beam source parameters tuning and for the beam transmission control; thus it will be beneficial for the entire device efficiency.

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