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Real-time reconstruction of plasma density profile based on deep neural network

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In magnetic confinement fusion devices, e.g., Tokamak, plasma position measurements play an important role in the safety protection and the prevention of disruption. Plasma density profiles can be used as important reference for calculating plasma positions. Therefore, real-time reconstruction of plasma density profiles has been attempted by many researchers. In this paper, a deep neural network is used to process microwave reflectometer measurement data and reconstruct the density profile in real time. The input layer of the deep neural network has 10,000 nodes and accepts in-phase (I) and quadrature (Q) data from microwave reflectometer measurements. The encoder of the network is a Multi-Layer Perceptron (MLP), and the decoder uses a Transformer model based on a self-attention mechanism. The MLP contains two hidden layers. Each hidden layer includes a linear operation layer and a nonlinear operation layer using the ReLU nonlinear activation function. The encoder extracts from the input data through nonlinear mapping. The Transformer decoder further decodes these features and generates the final reconstructed plasma density profile through the linear output layer. Compared with algorithms using classic neural networks, deep neural networks have significantly improved training efficiency, calculation speed, and reconstruction accuracy.

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