Neural networks for fast soft X-ray tomographic inversions in tokamaks

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Reconstructing the local plasma emissivity in the soft X-ray (SXR) range 0.1 – 20 keV can be very useful to access essential information on particle transport, magnetohydrodynamic activity or impurity content in tokamaks. In particular, radiative cooling of heavy impurities like tungsten (W) could be detrimental for the plasma core performances of ITER and developing robust SXR diagnostics is thus a crucial issue for monitoring the impurities and the prevention or their central accumulation. 2D tomography is the usual method to access the local SXR emissivity from line integrated measurements of two or more cameras viewing the plasma in a poloidal cross-section. This mathematically ill-posed and quite challenging problem is traditionally solved using Tikhonov regularization, such as the minimum Fisher information method implemented on the ASDEX Upgrade, TCV and WEST tokamaks [1]. However, real-time impurity control will require fast inversion methods while Tikhonov regularization needs relatively significant computational time, although many efforts have been performed in the direction of real-time applications [2].

Neural networks have been recently used for plasma tomography with JET neutron camera [3] and bolometers [4], showing promising results in terms of computational time as well as quality of reconstruction. Thus, the aim of this contribution is to investigate the use of neural network for fast soft X-ray tomographic reconstructions in the prospect of real-time impurity control in tokamak plasmas. Using a large database of various synthetic emissivity phantoms to train the neural network, the robustness of the inversion will be investigated and benchmarked with traditional Tikhonov regularization techniques [5]. The influence of the network parameters (neuron activation function, hidden layers, regularization procedure…) will be studied with a specific attention to the net gain in computational time, to the robustness of the method with respect to the experimental noise in the measurements and to the intrinsic limitations of such approach.

Acknowledgments. This work has received a financial support from the POLONIUM collaboration program between the French and Polish Ministers of Science.

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