Plasma Monitoring and Control with Real-Time Tomography at JET

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The use of real-time tomography at JET opens up new possibilities for monitoring the plasma radiation profile and for taking preventive or mitigating actions against impending disruptions. For example, the observation of an intense radiation blob at the plasma core, which is a sign of impurity accumulation in that region, can be used to trigger an alarm in the real-time control system. By monitoring the radiated power in different plasma regions, such as core, edge and divertor, it is possible to set up multiple alarms for the radiative phenomena that usually precede major disruptions. The approach is based on the signals provided by the bolometer diagnostic, which comprises a horizontal camera and a vertical camera with multiple lines of sight. Reconstructing the plasma radiation profile from these signals is a computationally intensive task, which is typically performed offline during post-pulse analysis, and may take several minutes to produce a single frame. To reconstruct the radiation profile in real-time, we use machine learning to train a surrogate model that performs matrix multiplication over the bolometer signals. The model is trained on a large number of sample reconstructions available offline and, when online, it is able to compute the plasma radiation profile within a few milliseconds in the resource-constrained environment of the real-time network. The implementation has been further optimized by computing the radiated power only in the regions of interest. The approach has been brought live in a recent experimental campaign and the results show that, during uncontrolled plasma termination, there is an impurity accumulation that migrates from the edge to the core, which eventually leads to a disruption by radiative collapse. On the other hand, a threshold-based alarm on core radiation, among other options, is able to anticipate a significant fraction of such disruptions.

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