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Strategy for the real-time detection of thermal events on the plasma facing components of Wendelstein 7-X

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Wendelstein 7-X (W7-X), the most advanced fusion experiment in the stellarator line, aims at demonstrating the feasibility of the stellarator concept as a future fusion power plant. It is planned to restart operation by the end of 2021 with a high heat flux divertor and water-cooled plasma facing components (PFCs) to demonstrate steady-state operation. With plasma energy limits starting at 1 GJ and gradually increasing to 18 GJ over several experimental campaigns, the PFCs have to be protected from overheating. For that, a fully autonomous system is required in order to prevent damage to the plasma facing components due to thermal events.

During the last experimental campaign, when W7-X was equipped with inertially cooled test divertor units, extensive experience was gained with the preliminary design of the thermal event detection system. By then, the system was not yet real-time capable and it was not fully automated, requiring manual supervision between discharges. This experience, however, allowed to prove the validity of some design concepts and to define the new strategy towards the protection of the machine in steady-state operation, when the system will be connected to the Interlock System and the feedback control.

In this work, the design of the real-time thermal event detection system for W7-X for steady-state operation is presented. The system is based on the thermography and video diagnostics to monitor the divertor units, the baffles, and the wall heat-shields and panels. It will be implemented on a real-time system and integrated in CoDaC's safety infrastructure. The system relies on computer vision and machine learning techniques to perform a spatio-temporal analysis to detect and classify the thermal events and to perform a risk evaluation. The results and the main conclusions drawn from the analysis of the data from the past campaign are reported.