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Real-time implementation in JET of the SPAD disruption predictor using MARTe

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One of the major problems in present tokamaks is the presence of disruptions. The disruptive event can produce serious damage to the device due to the emission of large quantities of energy to small areas of the plasma facing components and the strong electro-magnetic forces produced. Mitigation techniques must be applied to prevent or reduce this damage. Obviously, a pre-requisite for mitigation techniques is the existence of accurate and reliable disruption predictors. In this paper, the real-time implementation in JET of a new type of disruption predictor is presented. The new predictor, Single signal Predictor based on Anomaly Detection (SPAD), does not require past discharges for training purposes. The implementation is based on the Multi-threaded Application Real-Time executor (MARTe) framework. MARTe implementations consist of several software blocks called Generic Application Modules (GAMs) that can be chained in series or parallel. The implementation consists of 6 configurable MARTe GAMs that are executed sequentially. These GAMs process the Locked Mode signal sampled at 1 kHz every 2ms using the latest 32 samples. The process includes the calculation of the Haar Wavelet Transform approximation coefficients, the Mahalanobis distance of a feature vector with respect to a cluster formed by all the previous feature vectors, and an outlier factor depending on the mean and standard deviation of all previously calculated Mahalanobis distances. Due to the real-time requirements, some optimizations over the original algorithm were implemented, including: calculation of Haar approximation coefficients in one step, independently of the Haar transform level applied; and updating the mean, standard deviation and covariances used in the Mahalanobis distance and the calculation of the outlier factor. All this processing is performed in less than 1ms. Analysis over all JET's ITER-like Wall campaigns show that SPAD has better prediction results than the Advanced Predictor Of DISruptions (APODIS) and the Locked Mode Predictor based on Threshold criterion (LMPT) with 8.98% of false alarms, 10.60% of missed alarms, 3.18% of tardy detections, 83.57% of valid alarms, 2.65% of premature alarms and average anticipation time of 389 ms. The optimizations, performance results, and possible improvements will be presented.

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