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Rapid prototyping of advanced control schemes in ASDEX Upgrade

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The integration of advanced control schemes is becoming more important as the development of fusion experiments progresses.
The ASDEX Upgrade discharge control system (DCS) is designed to be adaptable via configuration, no recompilation is necessary to change the behaviour of the control system.

In order to enable advanced control schemes the required information has to be available during the discharge. With the DCS satellite concept the control system can easily be extended by including e.g. diagnostics, actuators and data processing nodes.

In this paper the extension of DCS for rapid prototyping of control schemes is discussed.
For tokamak operation disruptions are posing a major threat especially for large devices such as ITER.
Therefore disruption avoidance is an active field of research and the inclusion of avoidance schemes into DCS as part of exception handling is ongoing.
For the case of H-Mode density limit disruptions an avoidance scheme using central heating has been implemented and successfully tested on ASDEX Upgrade.
To easily add and modify input signals used for the avoidance scheme a new application process (AP) has been implemented which uses the C++ Mathematical Expression Toolkit Library (ExprTk), which enables the inclusion of run-time mathematical expressions into DCS.
The AP is operated separate from the central DCS as a DCS satellite, which allows modular inclusion of e.g. diagnostics, actuators and data processing nodes.
This is done to be able to test and validate the calculations without having to make changes to the central DCS.
For the disruption avoidance scheme the calculated signals, namely the confinement scaling $H_{98,y2}$ and the empirical critical edge density fraction $n_{e,edge}/n_{e,edge,crit}$, are evaluated in a state space which defines an \textit{area of disruptivity} which the scheme tries to avoid.
In case the discharge approaches this area central auxiliary heating is requested from actuator management.
The heating is continuously increased with decreasing distance up to full allocated heating power when the border is reached.
The avoidance scheme has been successfully demonstrated on ASDEX Upgrade exploiting these new features for rapid development and testing.
It is envisioned to apply the same methods for testing and demonstrating of other control schemes before they are included into e.g. exception handling.

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