Real-time tokamak simulations for plasma state reconstruction with minimal diagnostics.

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Abstract:
A future DEMO will have to rely on a minimal set of diagnostics to provide real-time information about the plasma needed for feedback control. A technique is presented to merge real-time diagnostic data with real-time plasma evolution models in order to obtain a reliable real-time plasma state estimate despite this scarcity of diagnostic data.

In this technique, a physics-based predictive model provides an estimate for the plasma state based on the state at the previous time step. Measurements from real-time diagnostics are subsequently used to correct this prediction. This technique is markedly different from traditional practices of equilibrium reconstruction, since the time evolution of the plasma is now explicitly taken into account and “inversion” of data becomes unnecessary. The method is well known and widely used in many fields of engineering, where it is known as a dynamic state observer or Kalman filter.

A dynamic state observer for the tokamak plasma profiles has been developed and which makes use of the real-time capable plasma profile evolution code RAPTOR [1]. It has been implemented on the TCV and ASDEX-Upgrade tokamaks and is undergoing validation and testing. Results will also be shown for ITER simulations, demonstrating accurate profile reconstructions with relatively few radial measurement points.