**Application of a sparse sensor placement technique to the limited diagnostic set in DEMO**

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In DEMO, a demonstration fusion power plant, the amount of diagnostics will be reduced compared to current experimental nuclear fusion reactors. A sparse sensor placement technique [1] is used to deal with the limited diagnostic set for the case of spectroscopy, required for wall heat load control. Experimental camera data from the MANTIS system [2] at TCV [3] is used to create and verify a synthetic diagnostic approach. The synthetic diagnostic consists of a set of lines of sight looking at the divertor leg, with the aim of identifying the CIII emission profile. However, the method is expected to be applicable to other diagnostics as well.

The sparse sensor placement algorithm takes as input the radiation measured for a large set of lines of sight, resolved over a range of timesteps. A singular value decomposition (SVD) is performed to obtain a number of eigenmodes, or “eigen-emission profiles”. Then a pivoted QR-factorization is done to obtain the optimal sensor locations for reconstruction of the emission profile. Using the measurements of this limited set of sensors, the whole emission profile along the leg is reconstructed by multiplying the measured radiation of only those few lines of sight with their corresponding eigenmode. We demonstrate that it is feasible to use a calibration based on either data from previous experiments or simulated data from SOLPS. For DEMO, this means that a line of sight selection and set of eigenmodes can already be calculated before experiments are performed. This method can also be applied to reconstruct other profiles from emission measurements by adding them in the SVD, if they have sufficient relationship to the shape of the emission profile. For example, the peak target current density obtained with Langmuir probes can be reconstructed using the synthetic spectroscopy measurements.

[1] Manohar, K., et al. "Data-driven sparse sensor placement for reconstruction: Demonstrating the benefits of exploiting known patterns." *IEEE Control Systems Magazine* 38.3 (2018): 63-86.

[2] Perek, A., et al. "MANTIS: a real-time quantitative multispectral imaging system for fusion plasmas." *Review of Scientific Instruments* 90.12 (2019): 123514.

[3] Reimerdes, H., et al. "Overview of the TCV tokamak experimental programme." *Nuclear Fusion* 62.4 (2022): 042018.