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Network identification of the design structure matrix with application to STEP

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Design structure matrices (DSMs) represent the connections between elements composing a system. In fusion, they are used to visualize the dependencies between various plasma variables, processes, states, and events and they serve as a basis for synthesizing supervisory controllers. A DSM representing the existence and absence of these plasma relations has been constructed after strong consultation of experts [1]. The disadvantage of building the DSM purely on the basis of expert knowledge is that it only captures exactly that what these experts think is important.

In this work, we show that a DSM can also be obtained from data only, by applying dynamic network identification methods. The plasma is viewed as a network in which the dependencies between the plasma properties are represented as the edges between nodes. The interconnection structure of the network is equivalent to the DSM and can be identified from sensor and actuator data, without explicitly estimating the exact dynamics. We extend the Bayesian model selection method of [2,3] to include excitation signals and use this data-driven network method to identify the interconnection structure.

We apply this method to a simulation example, where we identify the particle flow within the five-chamber tokamak model of STEP. The plasma in the reactor is modelled as a dynamic network with five inputs (the gas flux inlets) and 12 measured outputs (the number of neutral and plasma particles). The internal relations between the measured variables are identified with the network identification method. As a result, the DSM representing the gas and plasma particle flow within the tokamak is identified from simulation data. This illustrates the potential of using dynamic network theory for identifying DSMs from data.

References

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