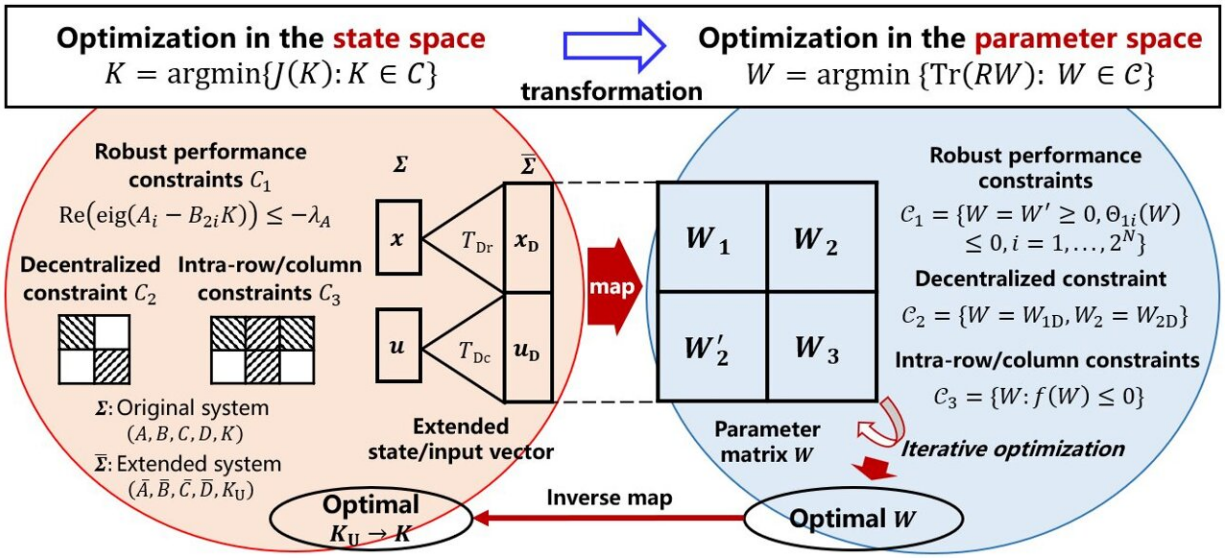
Integrated optimal design method of complex electromechanical systems

May 19 2022, by Zhang Nannan



The schematic illustration of the proposed structured optimal control method. Credit: NIMTE

Integrated optimal design can accelerate the iterative design process of complex systems and enhance their overall performance. Through lumping the mechanical, electrical and control parameters into the feedback gain matrix of the dynamic system and solving them efficiently based on the optimal control theory, the flexible manufacturing line can obtain the optimal performance by quick reconfiguration.

However, the feedback gain matrix in complex electromechanical systems has structural constraints due to mechanical structure, driving scheme, control structure, etc. It is difficult to solve the optimization problem directly by algebraic Riccati equation. This limits the application of optimal control theory in the integrated optimization design of electromechanical systems.

Researchers from the Ningbo Institute of Materials Technology and Engineering (NIMTE) of the Chinese Academy of Sciences (CAS) have proposed a structured optimal control method based on parameter space optimization.

According to the study published in *IEEE Transactions on Cybernetics*, the feedback gain matrix with intra-row constraints and intra-column constraints was transformed to an unconstrained decentralized feedback gain matrix.

Subsequently, a parameter space including the system state and control input was designed. In this way, the rules for mapping the system dynamics and feedback structural constraints from the state space to the parameter space were proposed, thus transforming the original non-convex structural optimal control problem to a tractable problem which can be efficiently solved with iterative convex programming techniques.

In the numerical process, the constraint supplementary logic was improved for the iterative dual-simplex linear programming algorithm. This allows the generation of multiple cutting planes at a single iteration, which improves the calculation efficiency.

The proposed structured control method shows great potential in the integrated optimal design of rigid-flexible coupling systems, redundant drive systems and underactuated systems.

More information: Liming Yuan et al, Parameter Space Optimization for Robust Controller Synthesis With Structured Feedback Gain, *IEEE Transactions on Cybernetics* (2022). DOI: 10.1109/TCYB.2022.3166775