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Title

Multi-Objective Controller Optimization and Robustness Analysis by the Example of Electro-Mechanical Flight Surface Actuation

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Abstract

The world is full of optimization problems, and engineers of different disciplines are regularly faced with the challenge of solving them for the technical application. In case of optimization of controller gains, the evaluation of the performance and stability of the control loop is necessary. There is rarely a reference control available against which the results can be compared. Likewise, it is not easy to evaluate whether the optimization result is a local or global minimum. Therefore, the application in practice also requires a check whether the control meets the previously set requirements. This also includes checking whether the behavior is still satisfactory with regard to disturbances, model uncertainties and measurement inaccuracies.

This paper describes the adaptation of a software environment for Multi-Objective Parameter Synthesis [1] for the purpose of controller optimization. To this end, suitable criteria for the evaluation of the control loop with respect to accuracy, oscillation behavior and stability margin are defined. A visual evaluation of the criteria in parallel coordinates is conducted, in which the conflicts of competing criteria become clear. In order to check the robustness of the optimized control loop, a worst-case analysis is performed for which measured parameters and plant parameters are subjected to uncertainties in a defined range. The search algorithm is then used to find the respective worst-case constellation of the uncertainties that maximizes a single criterion, e.g. that causes the maximum degradation of the control loop's performance. By carrying out this analysis for all criteria defined, it results in several worst-case constellations of the uncertainties. If the criteria still meet the predefined requirements, this confirms the robustness of the control with regard to uncertainties.

Research work is conducted at the Institute of System Dynamics and Control of the German Aerospace Center (DLR) on the design and optimization of a torque control for electro-mechanical flight surface actuation [2]. The described optimization methods are illustrated by means of this application example.

References

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