Delay Compensating Chain Predictors for Bilinear Systems with Power Systems Applications

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Abstract: This talk provides a new feedback control method to compensate for arbitrarily long constant input delays in bilinear control systems, based on dynamic extensions that eliminate the need to compute distributed terms that occur in previous traditional predictor-based delay compensation methods. The dynamic extensions are called chain predictors, and are composed of unperturbed copies of the original systems running on different time scales and other stabilizing terms. Our method is motivated by the ubiquity of input delays in many engineering applications, and the bottlenecks that arise when using standard feedback controllers that were not designed to compensate for the input delays. Our work provides novel formulas for lower bounds on the required number of chain predictors that are expressed in terms of the lengths of the input delays and the vector fields defining the systems. Our stabilization theorems ensure robustness to suitably bounded model uncertainty or sensor noise, in the sense of input-to-state stability. This can model cases where precise measurements of the current states of the systems may not be available. By relaxing the standard requirement that the dynamics grow linearly in the state, our method replaces the infinite dimensional approach of standard exact predictors by a finite dimensional approach that is based on only a finite number of chain predictors while also covering bilinearities. We illustrate our method using a model of a grid connected three-phase photovoltaic inverter, of the type that are used for grid integration in renewable energy sources. We show how the dynamics are oscillatory and unstable when the input delays are uncompensated, but that they enjoy desirable convergence properties to prescribed equilibria using a small number of chain predictors. This talk is based in part on the speaker's joint work https://doi.org/10.1016/j.sysconle.2021.104933 with Profs. Mehdi Farasat, Miroslav Krstic, and Michael Malisoff.

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