Stabilizing Predictive Control with Dynamic Weights

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1 Extended abstract

Recently, stabilizing multistep predictive controllers have been presented in [1]-[3] to overcome the stability limitations of standard predictive controllers, e.g. GPC (*Generalized Predictive Control*) [4]. It is well known, in fact, that GPC can guarantee closed-loop stability only in particular and limiting cases, viz. very large control horizon and vanishingly small control effort weight (see several examples in [5]). Exploiting the results of Kleinman [6] and Kwon-Pearson [7,8] on the stabilization of linear plants via *state-feedback* Receding Horizon Control (RHC), a novel approach to the design of stabilizing *dynamic feedback* controllers has been independently derived in [1,2] and [3]. The approach is based on minimizing a quadratic performance index defined over a finite prediction horizon subject to the constraint that inputs and ouputs match the desired reference values beyond the chosen horizon. The resulting controller, referred to as *Stabilizing Input-Output RHC* (SIORHC) in [1]-[2], is essentially equipped with two design knobs, viz. prediction horizon length and control effort weight, which allow tuning of the control performance. It has been shown that SIORHC stabilizes any stabilizable linear plant provided that the prediction horizon length is chosen larger than or equal to the plant order.

The stability results on SIORHC are limitative in that they do not insure stability of dynamic weights if dynamic weights are used in the control design process. In most control design methodologies, like GPC, LQG, H_∞ control, dynamic weights can be added with no harm for stability and the relative extension of the synthesis equations turns out to be trivial. In contrast with this, to provide a stabilizing version of SIORHC equipped with dynamic weights is far from being trivial. In fact, the terminal output constraints must be correctly formulated so as to guarantee the desired stabilizing property to the resulting control law.

We shall show that, once the above constraints are properly formulated, the problem of synthesizing SIORHC with dynamic weights is the same as constructing SIORHC for a *Controlled Autoregressive Integrated Moving Average* (CARIMA) plant with a suitable $C(z)$-innovations polynomial.

In [1]-[3] SIORHC has been presented for CARI (*Controlled Auto Regressive Integrated*) plants or, equivalently, within a deterministic setting. The aim of the paper will be then to extend SIORHC to CARIMA plants and hence to the presence of dynamic weights as well.

The paper will be organized as follows. First, a regulation problem will be formulated for CARIMA plants, solved and its stability properties analysed. Next, the 2DOF (2-Degree-Of-Freedom) servo problem will be addressed.

It will be shown that SIORHC can be extended to a stochastic framework with the twofold objective of including coloured disturbances and dynamic weighting in the problem formulation. Hence, SIORHC can provide an effective tool for the design of stabilizing dynamic feedback controllers which optimize a quadratic performance index defined over a prediction horizon of finite length. Further, the existence of a suitable algorithmic reformulation of SIORHC will make it computationally feasible for on-line control design in adaptive control.

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