Multirate Generalized Predictive Control for Sampled-Data Systems

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Abstract. In the generalized predictive control (GPC) scheme, we study a practical case of multirate systems involving fast A/D conversion and slow D/A conversion. We formulate the GPC problem as a sampled-data one with the performance index expressed in terms of continuous-time signals, capturing the inter-sample behavior. We convert such a multirate sampled-data GPC problem into an equivalent discrete-time GPC problem and then give an explicit solution for the optimal multirate control law. In an example, we first compare performance of this multirate GPC controller with that using conventional discrete-time multirate scheme, then with those using single-rate sampling schemes at the fast and slow rates, thus establishing its advantages.

Keywords. Generalized predictive control (GPC), multirate systems, single-rate systems, sampled-data systems, digital control.

AMS (MOS) subject classification: 34K13 93C57

1 Introduction

Generalized predictive control (GPC) was originally proposed by Clarke *et al.* in 1987 [4]. The control algorithms derived there were based on discrete-time models using a discrete-time performance index. Because discrete-time control algorithms in fact are operating with A/D and D/A converters in a continuous-time environment, poor inter-sample behavior may arise due to the fact that the design is based on performance solely at the sampling instants. To improve inter-sample performance, several pieces of work have been done: Demircioglu and Gawthrop proposed the continuous-time generalized predictive controller (CGPC) in 1991 using continuous-time performance index and implementing continuous-time control law [5]; Lauritsen *et al.* in 1995 proposed to implement continuous-time GPC algorithms using the delta operator [6]. Basically, this way of getting a discrete-time control law works well only when the sampling rate is fast; poor performance may result when the prediction horizon is large or the sampling rate is slow.

A preferred approach is the *sampled-data design problem*: Design discrete-time controllers directly based on continuous-time performance criterion [3]. This approach has the advantage of capturing the inter-sample behavior and obtaining optimal discrete-time controllers directly in design. Such sampled-data design problems were considered by Masuda *et al.* in 1997 in the GPC