Accepted Manuscript

Virtual Disturbance Feedback Tuning

Diego Eckhard, Lucíola Campestrini, Emerson Christ Boeira

PII: S2468-6018(17)30167-0
DOI: 10.1016/j.ifacsc.2018.01.003
Reference: IFACSC 12

To appear in: *IFAC Journal of Systems and Control*

Received date: 4 July 2017
Revised date: 20 November 2017
Accepted date: 30 January 2018

Please cite this article as: Diego Eckhard, Lucíola Campestrini, Emerson Christ Boeira, Virtual Disturbance Feedback Tuning, *IFAC Journal of Systems and Control* (2018), doi: 10.1016/j.ifacsc.2018.01.003

Virtual Disturbance Feedback Tuning

Diego Eckhard[a,*], Lucíola Campestrini[b], Emerson Christ Boeira[b,1]

[a]Departamento de Matemática Pura e Aplicada, Universidade Federal do Rio Grande do Sul, Brasil
[b]Departamento de Sistemas Elétricos de Automação e Energia, Universidade Federal do Rio Grande do Sul, Brasil

Abstract

This paper presents a data-driven control method formulated for the disturbance rejection problem. Inspired on the Virtual Reference Feedback Tuning method, which is based on a tracking reference model, the proposed methodology, entitled *Virtual Disturbance Feedback Tuning*, is based on a disturbance model. Using only input/output data collected on the process (no process model) and a linearly parameterized controller, the optimal controller parameters are obtained through least squares, resulting in a closed loop system as close as possible to the disturbance model. Experimental results show the efficiency of the proposed methodology.

Keywords: Data-driven control, PID control, Disturbance Rejection, Disturbance Model, VRFT

1. Introduction

Data-driven control methods are techniques that adjust the parameters of controllers directly from input and output data, without using a model of the process. A common theoretical framework for these data-driven methods is given in [1]. Some of these methods are iterative: the parameters of the controller are refined from one iteration to other, using experimental data collected in closed-loop, until the optimal controller is achieved [2, 3, 4]. Others are "one-shot" - that is, they directly estimate the controller's parameters on the basis of one sequence of input-output data [5, 6, 7]. Among the one-shot methods, Virtual Reference Feedback Tuning (VRFT) [5] has been extended to output sensitivity and control effort minimization [8, 9] and widely applied for reference tracking in different applications [10, 11, 12, 13, 14, 15, 16].

Indeed, most of one-shot methods aim to solve a tracking model reference design problem where the objective is to obtain a closed-loop response as close as possible to a desired response defined by a reference model. However, in most industrial applications, disturbance and perturbation occurrences are more frequent than reference changes and the primary objective of the controller is to reject these effects efficiently. Yet, when a tracking model reference approach is used and the desired closed loop response is faster than open loop, the closed loop responds accordingly to reference changes, but the settling time to reject load disturbances is close to the open-loop settling time, which is slower than the desired closed loop response.

A model matching controller design for load disturbance rejection is presented in [17], where a *desired disturbance model* is defined, but it depends on the knowledge of the process model. Considering data-driven approaches, an adapted version of VRFT for continuous-time signals is presented in [18] where the load disturbance problem is addressed as a reference model design by rewriting the reference model as a function of the desired disturbance model and the unknown controller. The articles [19, 20] propose two and three degrees of freedom controllers for disturbance attenuation of Virtual Reference Feedback Tuning, but it is assumed that the disturbance signal can be measured. In [21] a robust controller design is applied through the application of IFT, where the optimization is performed considering the reference tracking term and other terms related to sensitivities, including the one from load disturbance. However, the authors do not define a desired disturbance model.

Once load disturbance rejection is most likely more common than reference tracking in industrial applications, a larger effort on designing data-driven methods to solve such problems is needed. Inspired by the VRFT formulation, this article presents the Virtual Disturbance Feedback Tuning (VDFT) method, which is based on a virtual disturbance signal computed from a desired disturbance model. The proposed method assumes that the disturbance signal cannot be measured and it is able to find the ideal controller for the disturbance rejection problem under ideal conditions. In the practical case, where signals are corrupted with noise and the controller structure is restricted to low order (for instance proportional-integral controllers), instrumental variables and filters are proposed to improve the quality of the controller. Sta-

*Corresponding author, Address: Av. Bento Gonçalves, 9500 - Prédio 43-112 - Agronomia - Porto Alegre - RS - BRASIL - CEP: 91509-900 - Phone +55 51 33087088.

Email addresses: diegoeck@ufrgs.br (Diego Eckhard), luciola@ufrgs.br (Lucíola Campestrini), emerson.boeira@ufrgs.br (Emerson Christ Boeira)

[1]This work was supported by CNPq/Brazil and CAPES/Brazil.