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Author: G. François S. Costello A.G. Marchetti D. Bonvin

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# Extension of Modifier Adaptation for Controlled Plants using Static Open-Loop Models

G. François<sup>a,b</sup>, S. Costello<sup>a</sup>, A. G. Marchetti<sup>a</sup> and D. Bonvin<sup>a</sup>

<sup>a</sup> Laboratoire d'Automatique

École Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland.

<sup>b</sup> Institute for Materials and Processes, School of Engineering  
The University of Edinburgh, Edinburgh EH9 3FB, UK.

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## Abstract

Model-based optimization methods suffer from the limited accuracy of the available process models. Because of plant-model mismatch, model-based optimal inputs may be suboptimal or, worse, unfeasible for the plant. Modifier adaptation (MA) overcomes this obstacle by incorporating measurements in the optimization framework. However, the standard MA formulation requires that (1) the model satisfies adequacy conditions and (2) the model and the plant share the same degrees of freedom. In this article, three extensions of MA to problems where (2) does not hold are proposed. In particular, we consider the case of controlled plants for which the only a model of the open-loop plant is available. These extensions are shown to preserve the ability of MA to converge to the plant optimum despite disturbances and plant-model mismatch. The proposed methods are illustrated in simulation for the optimization of a CSTR.

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## 1. INTRODUCTION

Process optimization consists in determining the values of input variables that maximize a given performance criterion (such as economic profit or product quality), while meeting all the safety, environmental and operational constraints. Although generally bounded, the values of these manipulated variables are typically not fixed at the design stage. The problem can be formulated mathematically as the following nonlinear program (NLP):

$$\begin{aligned} \mathbf{u}_p^* &:= \arg \min_{\mathbf{u}} \phi_p(\mathbf{u}) \\ \text{subject to } & \mathbf{g}_p(\mathbf{u}) \leq \mathbf{0}, \end{aligned} \quad (1.1)$$

where  $\mathbf{u}$  is the  $n_u$ -dimensional vector of inputs,  $\phi_p$  is the cost function, and  $\mathbf{g}_p$  is the  $n_g$ -dimensional vector of process constraints. Here, the subscript  $(\cdot)_p$  indicates a quantity related to the plant, and this problem will be referred to as the *plant optimization* problem.

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