OPTIMAL TUNING PARAMETERS OF THE DYNAMIC MATRIX PREDICTIVE CONTROLLER WITH CONSTRAINTS

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Abstract— **Dynamic Matrix Control Algorithm is a powerful control method widely applied to industrial processes. The idea of this work is to use the Genetic Algorithms (GA) with the elitism strategy to optimize the tuning parameters of the Dynamic Matrix Controller for SISO (single-input single-output) and MIMO (multi-input multi-output) processes with constraints. A comparison is made between the computational method proposed here with the tuning guidelines described in the literature, showing advantages of the GA method**.

Keywords— **Genetic Algorithm, Dynamic Matrix Control, Automatic Tuning, Constraints Management.**

I. INTRODUCTION

Model Predictive Control (MPC) refers to a class of computer control algorithms that utilize an explicit process model to predict the future response of the plant (Qin and Badgwell, 2003). A variety of processes, ranging from those with simple dynamics to those with long delay times, non-minimum phase zeros, or unstable dynamics, can all be controlled using MPC. MPC integrates optimal, stochastic, multivariable, constrained control with dead time processes to represent time domain control problems (see Camacho and Bordons, 2004; Maciejowski, 2002; and Rossiter; 2003).

The MPC algorithms usually exhibit very good performance and robustness provided that the tuning parameters (prediction and control horizons and move suppression coefficient) have been properly selected. However, the selection of these parameters is challenging because they affect the close loop time response, being able to violate the constraints of the manipulated and controlled variables. In the past, systematic trial-and-error tuning procedures have been proposed (see Maurath *et al.*, 1988; Rawlings and Muske, 1993; and Lee and Yu, 1994). Recently there are some works proposing alternative techniques of adjusting then automatically. In Filali and Wertz (2001) and Almeida *et al.* (2006) it was used the Genetic Algorithms (GA) to design the tuning parameters of the Generalized Predictive Control (GPC) applied in SISO and time-varying systems without constraints. Another tuning strategy that can be implemented in a computer was proposed by Dougherty and Cooper (2003) which developed easy-to-use tuning guidelines for the Dynamic Matrix Control (DMC) algorithm, one of the most popular MPC algorithm in the industry. DMC uses the step response to model the process, and it is also applied in SISO and MIMO processes that can be approximated by first order plus dead time models.

The main goal of this work is to tune the DMC controller parameters for SISO and MIMO dynamical systems with input and output constraints using GA, in order to optimize the time response specifications (overshoot, rise time and steady state error) and to guarantee feasibility of solutions. It also carries through a comparative study between the method proposed here and the tuning guidelines proposed by Dougherty and Cooper (2003).

This paper is organized as follows: Section 2 describes the classical formulation of the DMC algorithm with constraints and presents the automatic tuning guidelines proposed by Dougherty and Cooper (2003); Section 3 makes an overview of GA and shows the application of GA with elitism strategy for tuning of the DMC parameters; in Section 4 we make the comparison between the proposed method here and the method described in the literature; Section 5 presents the conclusions.

II. DYNAMIC MATRIX CONTROL (DMC)

In this section we formulate the predictive control problem and we present its solution from the DMC algorithm.

Let us consider a linear MIMO dynamic system with m inputs (u_l, l =1,...,m) and n outputs (y_j, j =1,...,n), that can be described by the expression:

$$y_j(k) = \sum_{l=1}^{m}\sum_{q=1}^{\infty} g_{jl}(q)\Delta u_l(k-q) \quad (1)$$

where g_{jl} is the step response of output j with respect to the input l, and $\Delta u_l(k)= u_l(k)-u_l(k-1)$, is the control signal variation. Let us denote by $\hat{y}_j(k+i)$ the i step ahead prediction of the output j from the actual instant k; and $r_j(k+i)$ is the i step ahead prediction of the set point with respect to the output j.

The basic idea of DMC is to calculate the future control signals along the control horizon h_c, i.e., determine the sequence $u_l(k+i)$, for l = 1, 2,...,m and i = 0,..., h_c - 1, in such a way that it minimizes the cost function defined by:

$$\sum_{j=1}^{n}\sum_{i=1}^{h_p}\left(\hat{y}_j(k+i) - r_j(k+i)\right)^2 + \sum_{l=1}^{m}\sum_{i=1}^{h_c-1}\lambda_j \Delta u_l^2(k+i) \quad (2)$$