Model Based Predictive Control Using Genetic Algorithms. Application to Greenhouses Climate Control*

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Abstract. Solving multivariables and non-linear problems with constraints is usual when dealing with control problems. The classical way to solve this was through the decomposition into less complex problems: sub-problems with less variables and through the use of linear approximated models. These methodologies can present good results, but for some, only a suboptimal solution with a poor quality can be reached. The aim of this work is to combine Model Based Predictive Control (MBPC), a powerful control technique, with Genetic Algorithms, a powerful optimization technique. This combination can overcome limitations when approaching very complex problems in an integral way. This work extends this application to Multi Inputs Multi Outputs modeled with state space representation (a general way to include a wide range of nonlinearities) and shows its application to Greenhouse Climate Control.

1 Introduction

Model Based Predictive Control (MBPC) is one of the most intuitive and powerful control techniques. This methodology can be summarized in a few words:

With a process model and its past behaviour, it is possible to produce predictions of the process dynamic evolution for different control laws. If we could set a cost for each one of these predictions, it would be possible to select the best control law to achieve a fixed objective.

This easy and intuitive way to describe how MBPC works has been the basis of its success in industry [15], [7], [13], [14], [2], [16], [6]. On the other hand, several research works and industrial applications have shown its control capabilities. This means that it is a very interesting methodology for process control.

When described in more detail, all of the controllers with this methodology, have three fundamental elements:

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1. A **Predictor** that supplies controlled variable predictions for different manipulated variable combinations (control law). These predictions are based on process information (model and variable mesures).

2. A **Cost function** that assigns a cost to each prediction depending on previous fixed objectives.

3. An **Optimization technique** to search for the best control law.

Usually the bottleneck of this methodology is the Optimization Technique. Accurate models commonly have to include non-linearities, even if linear models are accurate enough, a realistic cost function could introduce non-linearities. All these aspects generally produce fairly difficult optimization problems. A Genetic Algorithm (GA) is a competitive way to solve difficult optimization problems when the computing time is not a problem.

Therefore, combining MBPC with GA is a promising alternative to solve complex control problems. This alternative was already proposed and analyzed for SISO (single-input single-output) transfer function model with additional non-linearities such as saturation, dead-zone and backlash [11]. This work extends MBPC with GA to MIMO (multi-input multi-output) processes using a state space representation as a general way to model non-linear processes.

![Fig. 1. MIMO Control structure for Model Base Predictive Control with GA.](image)

### 2 MBPC using GA for MIMO models

MBPC control structure is similar in SISO (see [11]) and MIMO models (Fig. 1). In this case, MBPC elements: predictor, cost function and optimization technique are defined in the following way.

#### 2.1 Predictor

The state space representation of a process is a widely used way to model linear and non-linear processes:

$$
\dot{X}(t) = g(X(t), U(t), D(t)) \\
Y_u(t) = f(X(t), U(t), D(t))
$$

(1)