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MICROPROCESSOR-BASED MULTI-MODEL CONTROLLER FOR COMPLEX INDUSTRIAL SYSTEMS

A THESIS SUBMITTED FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

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To my parents

and my wife

بسم الله الرحمن الرحيم

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ABSTRACT

This thesis presents a multi-variable control scheme, refered as **Tracking Multi-Model Control** depending on the multiple representation of the process using linear models. The aspects of the multi-model control are :

1- **Location** which means positioning the models as close as possible to the process using the available process information then, classifying the models according to their capabilities to approximate the process behaviour.

2- **Control** in which the available models representing the process are used to generate a control signal to make the system track certain desired reference values.

This control is achieved in two steps;

a- The **Basic Control** which means generating a control signal based on each model separately.

b- The **Control Synthesis** of the final control signal applied to the process as a function of the basic control signals.

A dynamic system can be represented by several models, each of them is different in either the simplifications and the reductions involved or in the dynamic characteristics.

A new tracking location algorithm is proposed where an auxiliary input namely the "state correction" is calculated and applied to the models so as to minimize a location performance index which is a function of the difference between the process outputs and the model outputs.

The basic control is the control signal which minimizes a quadratic performance index function of the difference between the process variables and the corresponding desired trajectories.

The basic control of the model which gives the minimum value of the location performance index is applied to the process.

The tracking multi-model control scheme is tested by simulation and is also built around a multi-microprocessor system. A real time application is carried out on a binary distillation column in "Laboratoire d'Automatique de Grenoble".

The application results proved that the proposed algorithm is efficient and avoids some disadvantages of the existing techniques.

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u_x state correction vector

x_m model state vector

x_p process state vector

x_r reference state vector

y_m model output

y_o reference output

y_p process output

$D, F_x, F_y, Q, Q_m, R, R_m$ weighting matrices

CHAPTER 1

INTRODUCTION

1.1- Introduction

During the last decades, the research work on both the theoritical and the practical aspects of control of linear systems has been achieved extensively. However, the control theory is still insufficient for the application on nonlinear systems or systems with unknown parameters. Moreover, the development in the design of control systems is enhanced by the rapidly growing means of calculation offered by the computers.

The advent of microprocessors continues the trend towards lower cost computer control applications in the industry where the microprocessor-based systems can replace analog, digital and computer control systems.

A real revolution in the structural changes is made possible by the availability of the low cost computing power in small packages. This encourages the designers to utilize parallel processing in handling the control problem of complex processes. The multiple representation of the process is one way of this parallelism. The process can be represented by linear

This algorithm is implemented using a microprocessor system and tested on a binary distillation pilot plant in "Laboratoire d'Automatique de Grenoble".

1.3- Outline of the Thesis

The thesis is organized as follows:

Chapter Two is a survey on the multi-model control and its existing applications.

Chapter Three includes the development of the proposed algorithm of location and the complete multi-model control technique with this proposition. A simulation study is included and the results are also given.

In Chapter Four the hardware and the software of the implemented microprocessor-based multi-model controller is given. It also presents a simulation study on this system.

Chapter Five describes the binary distillation column and the real time application of the proposed algorithm on this pilot plant.

The general conclusions are summerized and presented in Chapter Six. Suggestions for further research are also given.

Two appendices are added.

Appendix A includes more details about the theoritical development of the proposed algorithm.

CHAPTER 2

MULTI-MODEL CONTROL

2.1- Introduction

The control engineer is always facing a challenging decision of choosing the proper control technique in any application . Among the factors affecting this decision are the performance of the control technique and its complexity.

It is always possible to find complicated control law when applied to the system results in a very good performance. However, the implementation phase of such complicated controllers may not be realized or becomes very expensive to realize.

Therefore, there is a compromise between the performance of the control technique and the necessary means to use it in a real application.

The multi-model control satisfies this objective since it is easy to apply and has already given satisfactory results (1 - 6) .

The multi-model control depends on the multiple representation of the process using linear models.

designer must decide on a criterion to evaluate the quality of the models so that they can be classified accordingly.

On the other hand, the control phase of the multi-model technique involves the following two steps :

1- Generation of the basic control signal for each model separately.

2- Control synthesis of the final control signal applied to the process. It can be synthesized either by choosing the basic control signal of the best model according to the location criterion, or by combining the basic control signals of the different models.

Magill (7) has introduced the multiple representation in the definition of optimal estimation for a system of unknown constant parameters.

A major work has been done in this field by Lainiotis (8-11). He proposed the Nonlinear Separation Theorm and the Partitioning which are considered the base of the multi-model control.

The structure of the multi-model control algorithm is shown in Fig. 2-1 . The models are used to elaborate the basic control signal which makes the process tracks the desired reference variables.

2.2.1- Multi-Model Control for Deterministic Systems

In the literature survey, Monnier (12) is the only one who participated in the field of control of