Methods, structures and strategies for real-time hardware and software design and implementation of control systems of mono and multivariable nonlinear processes

Habilitation thesis

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Octombrie, 2015

Abstract

The Control System field is one that attracts the interest and attention of many researchers and experts from more disciplinary and even interdisciplary fields, such as theoretical ones - mathematics, system theory, applied or industrial – chemistry, aeronautics etc. The interest is based on the fact that a new solution, or even an improvement of an old one, has a major impact in achieving final products.

Regarding the theoretical field, the present solutions could be divided in two main cathegories: general theoretical solutions and punctual solutions. A similar division could also be considered for the practical field: hardware/software general solutions, classical for the mass industrial production and advanced punctual solutions, present in special fields such as military or aerospace.

From the hardware and software point of view, top producers from the selected market (Rockwell Automation, Siemens, Omron, ABB, National Instuments etc.) offer modern support regarding general implementation flexibility and of computing powers. Still, there are no modules or special paquetes of multivariable processes control, and from the algorithm adjustment point of view, the offer stops in the PID option area, eventually with self tuning options.

So in reality there is still a considerable discrepancy between theory and practice, especially in mass production automatics because the physical processes, objects of automatic control, mainly have non linear behavement. More than once, the mathematical parts necessary to rigorously deal with non-linear problems is highly complex and requires special preparation.

Of course, there are especially interesting concerns regarding „connection", at a more general level, of the theoretical and practical field, here pointing out the research that Albertos and Sala made, Visioli, Landau etc. – in the field of process control and numerical solutions with a high degree of applicability.

This thesis centralizes the result and the research that the author has made in the automatics field and real time data acquisition systems, that have had and still have, the following major objectives: linear system control and mono and multivariable non linear systems control; research and industrial applications; telemedicine. Starting from the intention of theoretical-practical connection, the approaches have tried to respect the following imposed „principles": real time implementation (TR); realistic use of existent hardware-software systems, avoiding expensive solutions; using the maximum „classical" theoretical and practical elements. During the mentioned period of time (1997-2015) over 100 papers have been published in a large number of journals and conferences, some of which will be pointed aut in the thesis.

Structurally, the paper is formed of 10 sections and selective biography. The purpose has been to form the most complete image of these results, by taking over some detailed elements (formulas, figures, demonstrations) from the papers that the author has contributed to.

Chapter 1 is a short introduction of the approached field as well as the ideas pursued in the paper. Chapter 2 presents the concepts of the two base elements used in the majority of the obtained results – algorithm and performing control structures. Chapter 3, mostly theoretical, presents multiple-model structures as well as multiple-model typical issues. Applications and practical results regarding these structures are broadly presented in chapter 4. The focus will especially be on the results of multiple-model control structures results used in pressure control for ventilation systems that are disposed in series. Chapter 5 presents another suggested structure that has successfully been used in many applications – it is the one regarding non linear compensation.

Another field that the selected research has covered is the one about synthesis and projection of structures and management strategies for multivariable processes. This way, in chapter 6 some elements and multivariable management structures are detailed. Chapter 7, mostly practical, presents theoretical elements as well as examples of coupling regulation loops. The results connected by the continuous production lines, optimization of the ratio, etc. are included.

An important range of applications, developed especially in the last years, is the one about the Grid systems – included in chapter 8. Among the examples included here, there are the ones connected to the balancing of multiple systems generators, balancing VPP structures, as well as the ones about photovoltaic panels „fields".

Chapter 9 is dedicated to the presentation of the proposed results and developed during some projects whose fundamental purpose is the development of some elements that regard telemedicine: platforms, equipments etc.

The last section is dedicated to presenting perspectives and ulterior developments. The paper contains a bibliography that includes a selection of over 100 titles of papers and interesting important documentations, good part of them (personal ones) are the base of this thesis.

Most results and experimental stands obtained in publications, programs and research coordinated projects, have been included in the educational programs of some disciplines from the final years of the bachelor's and master's of the Automatics and Computer Engineering University Bucharest. Still, not a few times, research and discovered results have not been finalized due of lack of time. Certainly, this drawback will be overcomed by expanding the research collective with new coordinate PhD students.