Summary of Habilitation Thesis

From Classical Control to Cognitive Control

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My habilitation thesis presents the scientific, professional and academic works that I had the chance to be involved in, as member of Computer Science Department of the Faculty of Automatic Control and Computers, University Politehnica of Bucharest.

The "control algorithms" represent the keyword of my definition as researcher and academic becoming, being constantly involved in projects that implied VLSI control architectures, sliding control of hyper-redundant robots, fuzzy control, FPGA-based control, cognitive (voice) control and intelligent control of complex integrated systems. This subject has been the main focus of my research activity starting from my PhD studies and until now. Being a very dynamic and completely challenging domain, my research activity has performed in the context of national projects in which I participated as a member or as coordinator. The main research directions in which I am involved can be summarized as: *implementation of fuzzy models for controlling complex systems; implementation of control algorithms; VLSI control architectures; algorithms for embedded systems implementation; implementing control algorithms for medical devices; integrating complex systems dedicated to rehabilitation of patients; e-Government frameworks and services.*

Control engineering is dedicated to the implementation of control systems that would facilitate obtaining certain required performances, related both to the quality of the process evolution over time, to satisfy particular criteria of minimum power consumption or minimum development time. The strategy and the implementation techniques depend largely on the type of process that is being conducted: chemical, mechanical or electrical classical-type processes, or modern systems, based on advanced robotic structures, complex traffic-management systems, neuro-cyber systems etc. In most of these cases, the parameters that appear when conducting the process are analogue and processing them in digital format involves introducing analogue-numeric and numeric-analogue converters that would allow implementation of numerical algorithms. In fact, the implementation techniques are based on using digital controllers whose configuration guaranties attaining the desired performances. In many applications, the implementation of these controllers is based on the use of microcontrollers whose resources and switching times meet the requirements. However, when conducting modern, complex processes,

requirements related to the complexity of driving algorithms and restrictions imposed by switching times create extremely severe conditions which, to a large extent, are not satisfied by classical microprocessors.

In these circumstances, the use of VLSI techniques that offer a single *chip* as technological support, with dedicated architecture and arithmetic, increases the quality of implementation, due to high speed in parallel-type processing of arithmetic operations, the increased reliability, the reduced effects of disturbances caused by noise, increased sensitivity and lower cost. All these elements lead to a substantial increase of digital controllers implemented through VLSI technologies. My thesis reveals all this aspects and my concern and devotion to this topic.

Hyper-redundant robotics had also a special place in my research. In this context, the habilitation thesis presents my accomplishments in finding robust solutions in designing, modelling and controlling robotic arms belonging to the class of hyper-redundant robots. They represents one of the most attractive domains of robotics during the last decades. The hyper-redundant arms are a class of arms that can achieve any position and orientation in 3D-space. The research contributions and some proposed solutions are presented here, underlying the articles where my work was published and emphasizing its impact.

Another aspect of my work regards e-Government frameworks, due to some projects developed together with Fraunhofer Institute for Open Communication Systems from Berlin. The thesis presents the results of some projects as "*E-CAESAR nPA Connector*", "*E-CAESAR SETUP*", "*Extension EU Service Directive (EUSDRO)*", "*E-CAESAR PrO*", "*eCAESAR eSafe POC*" made with Fokus Institute, Berlin, Germany

On the direction of "control algorithms for medical application", I have included a solution of cognitive control for an intelligent haptic robotic glove for the patients that suffered a stroke. The solution is very robust and is part of the results of a national project on medical rehabilitation robotics.

I should mention that my main concern will be to form a strong research team for a laboratory dedicated to intelligent secured solutions and hardware cryptographic implementations. The purpose of this team should be to develop innovative reconfigurable systems dedicated to the secured interoperability of different devices. I hope and I wish that the ideas and contributions presented in this thesis to be continued with new ones because my passion for research is a never ending story.

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