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Fundamental field: Engineering
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HABILITATION THESIS
– ABSTRACT –

Cross-domain research in systems engineering as innovation driver for the development of future technologies

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The habilitation thesis starts with a highlight of the main academic and industrial research landscape transformation influenced mainly by technology advancement, funding programs and industry-academia cooperation, over the last years. These factors have reshaped most research areas, especially the 3 research areas in which I have contributed: Process Control; Mechatronics, electrification and environmental monitoring; Automated Mobility, highlighting the essential role of technological innovation in solving global problems.

The habilitation thesis entitled *Cross-domain research in systems engineering as innovation driver for the development of future technologies* presents the research results , in these three areas, obtained after receiving the PhD title in 2011.

Chapter 1 presents the scientific results published in Process control focusing on three areas: distillation processes, rotary hearth furnace and wastewater treatment plants. Chemical processes are still reluctant to implementing advanced process control, therefore the research community needs to provide tools and successful results that can lean the balance towards new advanced control. My research was focused on plantwide control, a multi-layer control scheme, with applications on two distillation applications: Acetone-chloroform-benzene-toluene and an ^{13}C isotopic enrichment column. From first-principle modelling to MPC control algorithms, the results prove the advantage of this approach. Another domain of interest is the rotary hearth furnace used in the production of seamless tube pipes. Here an internal model control for the hydraulically driven robotic arm and the direct-current motor speed control were developed and their effectiveness proven through simulation. For the wastewater treatment plants we present that using a medium-fidelity first principle model and by carrying out an RGA analysis, a decentralized control strategy using PI controllers can be easily developed and tested before implementation, the control strategy giving good results in disturbance rejection and trajectory tracking.

Chapter 2 presents the scientific results published in Mechatronics, electrification and environmental monitoring. The research focused on Remote management of mechatronic systems, electrification and Environmental monitoring and energy efficiency. An architecture for the remote management of mechatronic systems that will allow users to take advantage of the potential of cloud computing is presented together with a review of Software as a Service solutions available on the market, solutions that can be integrated in the remote management. An interesting development has been the creation of remote laboratories in the cloud. Learners can access such laboratories to support their practical learning of mechatronics without the need to set up laboratories at their own institutions. The cloud infrastructure enables multiple laboratories to come together virtually to create an ecosystem for educators and learners.

The electrification brings many additional challenges especially in the ecological part. We challenge this part with a thorough analysis on the main parts of an electric/hybrid car and their recycling process, including also the waste electrical and electronic equipment (WEEE) Remanufacturing. For the environmental monitoring the research focused on a complete solution that allows the monitoring of ambient parameters such as Volatile Organic Compounds, temperature, relative humidity, pressure, and sound intensity levels both in indoor and outdoor spaces. The presented solution comprises of low-cost, easy to deploy, wireless sensors and a cloud application for their management and for storing and visualizing the recorded data. Monitoring of indoor ambient parameters is a prerequisite for supporting the energy efficiency increase in office buildings through advanced Building Automation Systems (BAS). These ambient parameters are mandatory in upper layer control systems that increase wellbeing while reducing energy consumption. The complete solution's operation and results were proven within an office space. This domain is covered by two international

research contracts (one Chips JU on power electronics and one Horizon Europe on battery management systems) that are now under implementation.

Chapter 3 presents the scientific results obtained within Smart Mobility. The research focused on Vehicle Control where an advanced control design tries to overcome the nonlinear dynamics and characteristic uncertainties of the Antilock Braking System (ABS) by taking them into account in the controller design stage. The effectiveness of the proposed solution is tested at first on a nonlinear mathematical quarter car model in Matlab/Simulink environment and then on a laboratory setup offering good braking results, improving the active safety the vehicle under heavy braking conditions. For the development of technical competencies, we developed Bosch Future Mobility Challenge, a technical hardware and software platform in the shape of an international student challenge that offers undergraduates the possibility to adapt or develop their own 1/10 scale automated vehicle algorithms and demonstrate the results within real-life scenarios. Two research contracts under implementation linked to the domain are presented together with their research goal (one Important Project for Common European Interest in Microelectronics and Communication Technologies (IPCEI ME/CT) on smart mobility solutions and one National Resilience and Recovery Project (PNRR) on solutions for smart and climate neutral cities).

To emphasize the strong link between the didactic and research part and the need to share the research results to students, each of the chapters 1-3 include also a section dedicated to the academic and scientific initiatives, where the courses that I teach, linked to the domain, are presented. The scientific conferences where I was part of the scientific committee are also presented during each section.

Chapter 4 presents the plans for the evolution and career development while the thesis end with chapter 5 that presents the final conclusions.