



Fundamental Field : Engineering Sciences
Specialisation : Electronics and Telecommunications

HABILITATION THESIS

- ABSTRACT -

**Contributions to the Development of Interdisciplinary Applications in
Electronics**

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This thesis highlights the professional development of candidate Lorant Andras Szolga for obtaining the right to coordinate doctoral research activities in the field of engineering sciences, specifically electronics, telecommunications, and information technologies. The thesis covers the work carried out by the candidate after obtaining the doctoral degree in December 2012, following the defense of a doctoral thesis titled "*Contributions to the Hardware Implementation of SVM Classifiers*", developed under the guidance of Prof.Eng. Lelia Feștilă, PhD, at the Technical University of Cluj-Napoca.

The thesis traces the candidate's professional evolution, focusing on the research conducted during this period, as well as the actions taken toward continuous personal development and the internationalization of the institution in which he is part.

All the activities carried out were primarily in the field of ***Electronic Engineering, Telecommunications, and Information Technology*** at the Technical University of Cluj-Napoca, as a faculty member of the Department of Electronic Fundamentals, Faculty of Electronics, Telecommunications and Information Technology, and as a member of the ***Optoelectronics Group***.

After obtaining my diploma in engineering, specializing in communications, in 2005, I completed two postgraduate specializations in electronics: one in "Design Techniques for Complex Electronic Circuits" and one in "Microelectronics and Electromagnetic Compatibility." By leveraging these specializations, I have incorporated a wide range of interdisciplinary applications into my work. This is reflected in scientific, professional, and academic achievements across a multitude of directions in the field of electronics and telecommunications, which involve the use of optoelectronic/photonic concepts and technology. The contributions from the submitted research are based on theoretical studies, design, practical implementations, testing, and validation of results.

This thesis, titled "***Contributions to the Development of Interdisciplinary Applications in Electronics***", is structured into two main sections: the first dedicated to scientific, professional, and academic achievements, organized into seven chapters (Chapters 1-7), and the second dedicated to the career evolution and development plan, organized into five chapters (Chapters 8-12).

Chapter 1 presents a summary of scientific achievements related to research and the involvement of undergraduate/master's/doctoral students in research; professional achievements related to research projects in which I was involved as a director/member and personal development; and academic achievements related to involvement in activities to improve the teaching process, the visibility of the Faculty of Electronics, Telecommunications and Information Technology, and the internationalization of the Technical University of Cluj-Napoca.

Chapters 2-7 present the scientific results, organized into six major research directions, based on the candidate's scientific publications indexed in recognized databases in the fields of Electronic Engineering, Telecommunications, and Information Technologies, such as WoS (Web of Science), Scopus, and IEEE Xplore. Thus:

Chapter 2 presents contributions to the development and testing of plastic optical fiber (POF) sensors in various fields, such as security, environmental monitoring, renewable energy, and industry. Innovations include intruder detection, flame and electric arc detection systems, humidity and chemical vapor detection, temperature sensing through POF-bimetal hybrid structures, and optimization of solar tracking for photovoltaic panels. Each solution utilizes the qualities of POF—flexibility, mechanical durability, and immunity to electromagnetic interference. This research positions POF sensors as suitable and cost-effective options compared to traditional sensors.

Chapter 3 synthesizes contributions in the medical field with innovative compact systems designed to address critical healthcare needs through portable and accessible solutions. Contributions include biosensors for blood and saliva testing, smart wearable devices with IoT capabilities, assistive technologies for vulnerable populations, laboratory automation tools, and intelligent imaging systems for diagnostic purposes. This chapter is based on eleven original studies. Each development focuses on accessibility, precision, and real-time data analysis, with the aim of early disease detection, patient safety, and laboratory efficiency. These contributions collectively highlight the role of integrated optoelectronics in making healthcare technology more accessible and supporting preventive care outside of traditional healthcare institutions. By combining innovative hardware and intelligent software, this chapter reflects the interdisciplinary progress in modern healthcare electronics and lays the groundwork for future personalized and remote health monitoring solutions.

Chapter 4 presents contributions to the development of portable and low-cost optical and electronic systems for monitoring water and food quality. Contributions include UV source and sensor-based systems for detecting nitrates/nitrites in drinking water and sterilizing it. In the food sector, a colorimetric method was implemented for monitoring pH changes in fresh juices, which was then complemented by a machine learning approach using UV spectroscopy for high-accuracy classification of food additives.

Chapter 5 presents contributions in the field of renewable energies, particularly those related to organic solar cells (OSCs). The chapter is based on 14 original articles that explore innovations in the active materials of cells and device architectures, ranging from single-component and homojunction solar cells to heterojunctions (bulk and bilayer), in both direct and inverted configurations. The emphasis is on electro-optical properties, highlighting how design strategies influence key parameters such as energy conversion efficiency, open-circuit voltage, and fill factor. Complementary research focuses on the development of automation platforms for manufacturing and testing, as well as the creation of sustainability frameworks for large-scale implementation. Overall, these contributions highlight a transition from materials-centered research to application-oriented photovoltaic engineering. The chapter not only sets a benchmark for next-generation OPV (organic photovoltaics) systems but also provides a foundation for integrating sustainable energy into emerging infrastructures.

Chapter 6 presents integrated contributions to the development of photonic systems based on eight original research studies. It covers the design and control of high-current infrared laser sources, as well as the implementation of versatile detection systems in the UV, visible, and IR spectral bands. On the detection side, the work covers thermal imaging, UV spectral analysis, visible spectrometry, and real-time object tracking using microcontrollers and optical sensors. These systems demonstrate low-cost and high-efficiency solutions with validated experimental performance.

Chapter 7 presents original research contributions to the development of intelligent electronic systems designed to improve urban life and environmental monitoring. Ten multidisciplinary applications are explored, including IoT-based smart lighting, parking, vehicle tracking, timetable displays, and emergency signaling. In parallel, autonomous systems are being introduced for home security, luggage security with NFC systems, sports activity monitoring, egg incubation, and greenhouse management. All systems developed, implemented, and tested are built on microcontroller platforms, with an emphasis on low energy consumption, wireless data transmission, and modular scalability. The chapter provides a comprehensive overview of integrated practical innovations that support the concepts of smart cities and environments.

The second part of the thesis outlines future career evolution plans and is organized into professional evolution (*Chapter 8*), scientific evolution (*Chapter 9*), academic evolution (*Chapter 10*), and future research directions (*Chapter 11*). *Chapter 12* presents the conclusions.