

MATHEMATICAL SCIENCES

Eltek S.p.A. - Innovative mathematical models and analysis in the design and production of sensors and mechatronic components

Funded By	ELTEK SPA [Piva/CF:00571280064]
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Context of the research activity	Development of mathematical models and machine learning algorithms for instruments such as sensors, capable of directly analyzing signals, and for mechatronic components of industrial products. Evaluation and development of various techniques useful for this purpose, such as generative AI, fluctuation theorems, and the theory of response to perturbations.
Objectives	The project concerns the development of physical-mathematical models and algorithms that can be executed by hardware and software integrated with the instruments intended to be designed —primarily sensors capable of directly analyzing signals as they are collected— along with other mechanical and electronic components for industrial production. In this context, particular attention will be given to the most innovative machine learning techniques, as well as those related to the typically anomalous behaviors of miniaturized systems and their responses to perturbations. This will help identify and implement solutions that are also energy-efficient, in line with the goals of the National Recovery and Resilience Plan (PNRR), with various nuances depending on the characteristics and applications of the instruments being developed. Comparison with experimental data from industrial research will be used to develop new theoretical tools, which in turn will support production strategies. These strategies will be considered alongside the analysis of the most suitable innovative solutions. The studies involved may impact digitalization, innovation, and competitiveness, as well as environmental and industrial production monitoring —key aspects of ecological transition. Moreover, accurate sensors capable of suggesting real-time solutions support sustainable mobility and represent a frontier in the development of technologies of medical interest. It will be taken into account that the study itself covers a broader range than the immediate industrial applications, as similar mathematical modeling problems are also found in basic sciences and other technological fields. The project will be carried out in close collaboration between the Polytechnic University of Turin and ELTEK S.p.A., a multinational company headquartered in Casale Monferrato (province of Alessandria), with laboratories and offices in several countries, including Poland, Switzerland, China, Germany, and the USA. This company

is a leader in nanotechnology, with particular interests in developing solutions for biomedical, automotive, transportation, and microelectronic applications.

**Skills and
competencies
for the
development of
the activity**

The basic knowledge obtained from courses in mathematics, physics, chemistry, engineering, and related fields is sufficient to begin the planned research. More in-depth knowledge of mathematical physics equations, or of the physics of complex and non-equilibrium systems, or of machine learning will be useful.