PhD in Metrology

Research Title: Artificial intelligence in Electric Properties Tomography

Funded by	INRIM

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Context of the research activity	Despite its widespread use, traditional MRI (Magnetic Resonance Imaging) is qualitative, meaning that the acquired images have to be interpreted by a specialist and this does not allow results obtained at different times and locations to be quantitatively compared. In addition, conventional MRI does not provide direct information about the nature of the pathology, nor does it quantify biomarkers. To address these issues, approaches to perform MR-based Electrical Properties Tomography (EPT) are under development, which should eliminate interobserver variability and reduce the need for invasive quantitative procedures (e.g. biopsies). In addition, EPT should enable new biomarkers to be identified for a plethora of pathologies that cannot be physically diagnosed and they should boost early disease detection. These approaches could be used to optimise the clinical path, to improve the quality of life of patients and to reduce the associated economic burden. Up to now, most applications of EPT procedures have aimed to verify the ability of algorithms to quantify the value of the investigated parameters against a point of reference. However, in order to become a clinical tool, EPT must be able to spot anomalous values in the presence of the physiological variability of such parameters. Therefore, a

	specific effort will be made to obtain, through in vivo MR acquisitions, a quantification of the dispersion of the parameters in healthy humans. Then, for a selection of pathologies, this information will be used to evaluate the suitability of the investigated parameters to act as reliable biomarkers. The exploitation of artificial intelligence to automatically interpret the values and distribution of each biomarker (or a combination of them) in the scanned region will be explored in depth. The activity will be developed in the framework of the European research project EMPIR 18HLT05 QUIERO "Quantitative MR-based imaging of physical biomarkers", in cooperation with the Artificial Intelligence Laboratory of the University of Ljubljana, Faculty of Computer and Information Science.
Objectives	Artificial intelligence has recently been exploited to perform EPT reconstructions, but it has not been used to obtain an automatic detection of pathological anomalies in the corresponding maps. The EMPIR project 18HLT05 QUIERO aims at quantifying the sensitivity and specificity associated to EPT. Such information, together with the uncertainty characterization performed throughout the project, will lead to the final goal: the realization of objective, comparable, MR-based quantitative imaging, where each pixel represents the numerical values of physical parameters that should fall within a range of "normal" values in order to be considered as compliant. During this research activity, the PhD student will work on specific tools, based on machine learning, to automatically identify, within EPT maps, small or distributed anomalies that would be difficult for human eye to recognize. Specific objectives are: - To develop, improve and implement numerical algorithms for use in EPT and to characterize their performance. - To make EPT suitable for practical use in the analysis of "high impact" clinical conditions, e.g. brain diseases. - To fully characterise EPT as a diagnostic tool under real-world conditions, including determining, for a selection of pathologies, the inter- and intrasubject physiological variability. The synergistic use of EPT and other quantitative MR techniques (e.g. MR fingerprinting) will be explored and specific computer-aided diagnostics approaches will be developed.

Skills and competencies for the development of the activity	The candidate should have a general background in Mathematics/Physics/Engineering. Priority will be given to candidates with specific expertise in: - artificial intelligence and, more specifically, in machine learning; - statistical data analysis, Bayesian techniques and inverse problems; - computational electromagnetics.