PhD in BIOINGEGNERIA / BIOENGINEERING - 39th cycle

THEMATIC Research Field: EXPANSION - EXPLAINABLE AI THROUGH HIGH ENERGY PHYSICS FOR MEDICAL IMAGING IN ONCOLOGY

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	Over the last decade, medical imaging in oncology evolved towards the personalization of patient treatment thanks to the use of advanced computational techniques, as Machine Learning (ML) and Deep Neural Networks (DNNs), coupled with radiomics and biomarkers identification to attain high diagnostic and therapeutic precision. However, despite their superior performance, ML/DNNs are often untrusted because of their complex structures, lack of interpretability, and black-box nature, thus demanding proper explanation and validation procedures before being used as supportive tools by clinical end-users.The main objective of the project is therefore to optimally describe the behaviour of ML models for tumour characterization and treatment outcome prediction, exploiting the support of novel methodologies based on explainable artificial intelligence (XAI), designed to explain and interpret the causal relationship between input features and outcome of a ML model. Uncertainties of the models will be also taken into account. Different pathologies will be considered (with a main focus on brain and lung tumours) to allow for reproduction of the XAI models on different use cases.XAI techniques will be implemented and validated usingthe High Energy Physics (HEP) domain as a testbed, as it offers a vast library of datasets with solid and well understood underlying causal theory, available also in the format of simulated events conformal to the data, ideal for a quantitative and measurable validation of XAI models; it

	is nowadays at the forefront of sophisticated big data analysis at the CERN Large Hadron Collider (LHC). The validated XAI models will then be applied to the oncology domain for an exquisite in-vivo patient-specific tumour description, by exploiting for the first time in an informed manner ML/DNNs tools to explain quantitative imaging radiomics or deep features selected by the model and their associations with clinical and biological information. Decreto direttoriale di ammissione a finanziamento prot. n. 961 del 30 giugno 2023 CUP master: D53D23004410001CUP: D53D23004410001
Methods and techniques that will be developed and used to carry out the research	Medical imaging data will be firstly collected from the publicly available dataset of the Cancer Image Archive (https://www.cancerimagingarchive.net/), exploiting datasets containing multi-parametric imaging data along with clinical/biological information and mainly focusing on head and lung cancers (two of the main widespread cancers) to allow for reproduction of the XAI models on different use cases.XAI methods will be then implemented and investigated by relying on literature-based approaches (e.g. SHAP, Grad-CAM, LIME) and/or implementing novel XAI models either incorporating inductive learning or adopting posthoc analysis. Uncertainties of the models will be also taken into consideration (as for example relying on Bayesian networks).The models will be implemented and validated on HEP dataset composed of Monte-Carlo ground truth simulations and collected data samples from the LHC experiments, through a key collaboration with CERN, INFN, University of Milano Bicocca and University of Perugia.
Educational objectives	Educational objectives include that:- The PhD student will be involved in educational courses provided by the PhD school of Bioengineering at Politecnico di Milano;- By working in a collaborative environment involving different high-standing research units, the PhD students will be able to interact with professionals coming from different sectors to make the most of XAI advantages available in both HEP and medicine.- The PhD student will be able to

	understand the main concepts of machine learning and XAI applied in medical imaging in oncology- The PhD student will learn how to implement andvalidate XAI models relying on HEP as a test bed.- The PhD Student will participate in national andinternational conferences and schools, as those provided by CERN. He/she will be also involved in producing manuscripts to be submitted in top-ranked peer-reviewed indexed journals in Open Access modality.
Job opportunities	After the PhD, different job opportunities will be available as Postdoc or Research Scientist in national or international institutions. Positions as clinical bioengineer will be also possible within clinical institutions making use of AI tools to improve patient care and clinical workflows.Careers related to machine learning applied to medicalimaging are recently evolving in many enterpriseorganizations and recently founded spin-off companies,demonstrating the excellence and actuality of the proposed project. Jobs as data scientists, big data engineers and machine learning engineers will be additional opportunities as the implemented and validated XAI models can be also replicated in other socially relevant fields (e.g. security and finance).
Composition of the research group	1 Full Professors 1 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	PROF. CHIARA PAGANELLI

Contacts
Prof. Chiara Paganelli chiara.paganelli@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad

Amount monthly	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The PhD student will be involved in educational activities along with teaching assistantship covering topics of advanc2022YS87H7 - Design and validation of an advanced delivery system for miRNAs and stem cell- derived extracellular vesicles for direct cardiac reprogramming through a mechanically- stimulated human cardiac scar model - DESIRE Decreto direttoriale di ammissione a finanziamento prot. n. 961 del 30 giugno 2023 CUP master: D53D23004410001CUP: D53D23004410001