



PhD in BIOINGEGNERIA / BIOENGINEERING - 41st cycle

THEMATIC Research Field: EXPLAINABLE ARTIFICIAL INTELLIGENCE FOR BRAIN MRI CLASSIFICATION: TOWARD TRANSPARENT AND CLINICALLY INTERPRETABLE MODELS IN NEUROLOGICAL DISORDERS

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

Motivations Artificial Intelligence (AI) has shown remarkable potential in classifying brain MRI data and detecting neurological disorders such as Epilepsy, Alzheimer's disease, multiple sclerosis, and brain tumors. However, most high-performing models act as "black boxes," offering limited transparency about their decision process. This lack of interpretability hinders clinical trust, validation, and regulatory approval. Developing explainable AI (XAI) methods is therefore essential to ensure that AI systems provide clear, interpretable, and reliable insights aligned with clinical reasoning. Objectives This research aims to develop explainable and trustworthy AI models for brain MR images classification in neurological disorders. Specific objectives are to:

- Design deep learning models with integrated explainability mechanisms (e.g., Grad-CAM, Layer-wise Relevance Propagation (LRP), etc.).
- Quantify and visualize the regions or features driving model decisions.
- Estimate model uncertainty to improve reliability and clinical confidence.
- Validate interpretability through comparison with radiological and pathological findings.



Methods and techniques that will be developed and used to carry out the research	The research will combine advanced machine learning, medical image analysis, and explainable AI methodologies applied to brain MRI data. The main techniques include: 1. Deep Learning Architectures: Development and optimization of convolutional and transformer-based neural networks for brain MRI classification across neurological disorders. 2. Explainability Frameworks: Integration of model interpretation techniques such as Grad-CAM, LRP, etc., to identify and visualize image regions contributing to AI decisions. 3. Uncertainty Quantification: Implementation of approaches (e.g., Ensemble, Bayesian, etc.) to estimate epistemic and aleatoric uncertainty, improving model reliability and robustness. 4. MRI Data Processing and Feature Extraction: Preprocessing pipelines for MR images (e.g., bias correction, normalization, registration, segmentation) and extraction of quantitative biomarkers for model input and validation. 5. Validation and Evaluation: Cross-validation on public and in-house datasets, comparison of AI-generated explanations with expert radiological annotations, and statistical assessment of interpretability and performance metrics. The PhD project will be carried out in cooperation with the Institute of Intelligent Industrial Technologies and Systems for Advanced Manufacturing (STIIMA) of the National Research Council.
Educational objectives	We provide doctoral candidates with high-level scientific training, fostering and refining research and problem-solving abilities by focusing on both theoretical and experimental skills. A PhD in Bioengineering will be trained to lay out, draft, and carry out original research by leading a research group or working in a team. The didactic offer of the PhD in Bioengineering



	(https://www.phdbioengineering.polimi.it/) will be integrated by schools and workshops specific to the research topic.
Job opportunities	The skills and expertise developed during the PhD Program are suitable for national and international academic institutions, research organizations and high-tech SMEs committed to innovation, fundamental/applied research and technical development both in imaging and AI. Examples: product specialist, application specialist, R&D.
Composition of the research group	2 Full Professors 2 Associated Professors 2 Assistant Professors 3 PhD Students
Name of the research directors	Proff. Giuseppe Baselli - Alfonso Mastropietro

Contacts	
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

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
Educational activity: The student will be encouraged to attend to courses at POLIMI or abroad 2 / 3 in International Schools. STIIMA-CNR will provide a desk and a PC to the candidate during the whole PhD period.

