POLITECNICO DI MILANO

PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 38th cycle

PNRR_352 Research Field: A COMPUTATIONAL LIBRARY FOR PHYSICS-INFORMED NEURAL NETWORKS

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	Data driven mathematical models are becoming a new pervasive technology. The mainstream approach to effectively implement them is based on artificial intelligence related techniques, such as machine learning and deep learning. However, major trade offs quickly arise: • in engineering applications this class of statistical models might be defined as black-boxes and their adoption in heavy regulated industries is not straightforward. • Nonlinear functional analysis has not yet developed relevant results to ensure that problems and solutions are well defined. • Uncertainty, robustness and trustworthiness quantitative evaluations do not have a general definition and a systematic approach. Hence, Physics-Informed Neural Networks (PINNs) appear to provide a higher level of reliability when it comes to algorithm explainability and certification. The goal of present project is to develop PINNs based on machine and deep learning algorithms and provide the first release of as set of mathematical functions for standardized treatment of PINNs implementation.This would be performed using all the major best practices in massively parallel processing in High Performance

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	Computing. This research contributes to the PNRR aim of increasing knowledge and competencies on advanced simulation and big data as a key enabling technology. It also fosters collaboration among universities and Industry.
Methods and techniques that will be developed and used to carry out the research	The research activity aims at developing innovative methods that combine computational and learning approaches to address meaningful problems in industry. It will develop both advanced physics-based and physics-aware models, in synergy with data-driven models based on deep and machine learning algorithms. The project will feature the design of a parallel PINNs mathematical functions (exascale computing project based) and the development of the software library.
Educational objectives	The research will be carried out in a researchers¿ team of experts in scientific computing, numerical analysis, software development, physics-informed machine and deep learning algorithms. The candidate will develop proficiency in parallel computing techniques and languages as CUDA and MPI, other than C++ and Python. An internship of at least 6 months at Leonardo S.p.a., Genova Fiumara, and/or Leonardo Helicopters, United Kingdom is planned. Therein, the student will interact with the research and development team of the company.
Job opportunities	The research addresses timely, innovative and advanced topics in Applied Mathematics, Scientific Computing, Data Science, Machine Learning, and software development. Scientists at the interplay of these fields are very likely to find a highly qualified job in industrial and business sectors, wherein the demand of such profile is continuously growing both in EU and US. Specific area of employment: development of in-house industrial company proprietary codes; aerospace and Defense design methods departments; CFD software houses.
Composition of the research group	5 Full Professors 6 Associated Professors 4 Assistant Professors 15 PhD Students
Name of the research directors	Carlo De Falco, Luca Dede'

Contacts
Prof. Luca Dede¿, luca.dede@polimi.it

Additional support - Financial aid per PhD student per year (gross amount)			
Housing - Foreign Students	**1st year**	**2nd year**	**3rd year**
	1500.0 € per student	0.0 € per student	0.0 € per student
	max number of financial aid available: 3, given in order of merit ..		
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

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Leonardo Spa
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year
1st year: max 1.902,38 euros
2nd year: max 1.902,38 euros
3rd year: max 1.902,38 euros

The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations.1 individual PC per student + several shared PC.
Access to one cluster with 32 processors and 384 GB RAM, and to several multi-processor servers and 1 individual desk per student are granted.