POLITECNICO DI MILANO

PhD in DATA ANALYTICS AND DECISION SCIENCES - 40th cycle

PNRR 630 Research Field: PHYSICS-INFORMED ARTIFICIAL INTELLIGENCE FOR SURROGATE MODELING OF COMPLEX ENERGY SYSTEMS

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 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	In the pursuit of optimizing energy systems for efficiency, cost-effectiveness, and sustainability, computational models play a pivotal role in simulating complex behaviors and predicting system performances. Traditional detailed physical models often demand significant computational resources, hindering real-time applications and extensive parametric studies. Surrogate models, powered by artificial intelligence (AI) techniques such as deep learning, offer a promising solution by providing rapid approximations of complex simulations. The research focuses on developing advanced AI surrogate models specifically tailored for the energy industry. These models are designed to either replace or augment traditional, computationally intensive simulators with AI-driven alternatives that promise improved accuracy and efficiency. Key to this endeavor is the integration of physics-informed machine learning techniques, which blend domain-specific knowledge with data-driven approaches to effectively model complex physical systems. This approach aims to enhance the accuracy of these AI surrogate models by ensuring they capture the fundamental dynamics of energy systems while adhering to physical laws and constraints. Additionally, the proposal incorporates active learning strategies to optimize data point selection, thereby improving model training and validation efficiency. This proposal emphasizes uncertainty quantification as essential in assessing the robustness and reliability of surrogate models within

	energy systems. By quantifying uncertainties arising from data and model assumptions, stakeholders can gain crucial insights for risk assessment and decision-making in energy system planning and management. Real-world case studies and evaluations will illustrate how the novel AI-driven surrogate models accelerate simulations, decrease computational burdens, and improve predictive precision. By showcasing the transformative impact of advanced AI methodologies, this research seeks to innovate the modeling intricate energy systems, fostering better decision-making and optimized operational performance in practical applications.
Methods and techniques that will be developed and used to carry out the research	Computational strategies developed in the research project will leverage on numerical approximation techniques, physics-driven AI methods (e.g., physics-informed neural operators, as well as progressive learning from multiple sources to sequentially incorporate diverse data types, or active learning), and uncertainty quantification strategies.
Educational objectives	The candidate will have the opportunity to collaborate with a wide research group across several Departments of Politecnico di Milano (e.g., Civil and Environmental Engineering, Mechanical Engineering) as well as with worldwide recognized research groups.
Job opportunities	Besides Universities, Research Institutes, and DeepTech companies in Europe and all-over the world, job opportunities are related to fields where experts in computational methods, data science, Engineering, as well as machine and deep learning, are requested.
Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 3 PhD Students
Name of the research directors	Prof. Andrea Manzoni

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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	750.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	ENI SpA - San Donato Milanese (MI)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	University of Washington, AI Institute for Dynamical Systems (Seattle, WA)
By number of months abroad	6

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

List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research

1. Dr. Francesco Cannarile, ENI Center of Excellence Data Science &Cross AI Products
2. Prof. Nathan Kutz and Prof. Steven Brunton, University of Washington, Seattle, US
3. Prof. Karen Willcox, ICES, University of Texas at Austin, USA
4. Dr. Mengwu Guo, University of Lund, Sweden

Additional support

Educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences):
financial aid per PhD student per year:
1st year: max 2.038,00 euro per student
2nd year: max 2.038,00 euro per student
3rd year: max 2.038,00 euro per student

Teaching and lab assistantship: availability of funding in recognition of supporting teaching and lab activities by the PhD student.
Further support is available for students who engage in activities of teaching or additional lab duties coherent with their academic mission and doctoral training.

The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

Computer availability:
1 st year:individual use
2 nd year: individual use
3 rd year: individual use

Desk availability:
1 st year:individual use
2 nd year: individual use
3 rd year: individual use