POLITECNICO DI MILANO

PhD in SCIENZE E TECNOLOGIE ENERGETICHE E NUCLEARI / ENERGY AND NUCLEAR SCIENCE AND TECHNOLOGY - 39th cycle

THEMATIC Research Field: ARTIFICIAL INTELLIGENCE AND STOCHASTIC SIMULATION FOR THE RESILIENCE OF CRITICAL INFRASTRUCTURES

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	CUP: D53D2300154 0006. Modern society depends on critical lifelines, like electric power and natural gas, telephone and other communication systems, water, wastewater and transportation systems (roads and highways, rail systems, ports, and airports). Many of these infrastructures are aging and are exposed to different natural hazards (e.g., earthquakes, tsunamis, hurricanes and floods), whose intensity and severity has been increasing in the past years, possibly due to climate change. Scenario simulation plays a key role for analyzing resilience and informing the investments on prevention, mitigation and recovery. However, it becomes computationally demanding when exploring the response of the complex Critical Infrastructures (CI) under uncertain disruptive events. Artificial Intelligence (AI) and stochastic simulation can be combined in a framework for simulating efficiently the response of an infrastructure exposed to an uncertain disruptive event, under uncertain operational and environmental conditions. The aim of the project is to develop such framework and the corresponding computational platform, to support designing and managing infrastructures. In the project, we focus in particular on the Energy Critical Infrastructures (ECI) for their pivotal role in supporting other infrastructures and

	society as a whole, in a scenario of energy transition.The research is financed by the MUR Progetto di Rilevanza Nazionale (PRIN2022) ?ARtificial Intelligence and STOchasTic simulation for the rEsiLience of critical infrastructurES (ARISTOTELES)?, within a consortium composed by Politecnico di Milano, Politecnico di Torino, Istituto Nazionale di Geofisica e Vulcanologia.It will be carried out also with the involvement of MINES Paris-PSL University, Centre de Recherche sur les Risques et les Crises (CRC), Sophia Antipolis (France), possibly within a Double/Joint Phd program which would lead to awarding a joint PhD or two PhD titles, one from Politecnico di Milano and one from Mines Paris ? PSL (framework agreement under preparation).
Methods and techniques that will be developed and used to carry out the research	Uncertainties affecting the infrastructure response to disruptive scenarios will be characterized and represented in mathematical terms. Bayesian Inverse Uncertainty Quantification (IUQ) will be used for building a robust uncertainty description, consistent with the (even possibly vague and imprecise) expert judgments and the (often scarce) field data available. The application of IUQ likely requires the reduction of the dimensionality of the infrastructure model, by identifying the variables, elements, environmental factors that affect most the infrastructure response: this will be accomplished by advanced sensitivity analysis methods capable of screening the input variables resorting to a limited number of model evaluations. The uncertainty so characterized (both aleatory and epistemic) will be propagated through the model of the infrastructure to provide the full spectrum of system responses during the stochastic disruption and recovery phases, and to calculate the performance metrics of interest. To cope with the computational demand for the solution of the dynamic, nonlinear, and high-dimensional models, efficient combinations of intelligent stochastic simulation strategies and AI methods will be implemented within stochastic simulation methods like affine invariant, interacting and multi-source Markov Chain Monte Carlo-MCMC samplers. AI methods (e.g., Kriging surrogate models, deep learning, regression and clustering techniques), meta-heuristics (e.g., Genetic

	Algorithms, sequential cooperative optimization), and data-driven approaches (distributionally-robust optimization, Scenario Theory) will be considered.
Educational objectives	To prepare a modern and professional expert in Risk and Resilience analysis of critical infrastructures, equipped with advanced technical skills of system analysis, modelling, simulation and artificial intelligence/machine learning.
Job opportunities	Safety specialist, risk analyst, risk engineer, risk manager, safety data analyst with competences fit for the risk-based design, operation, management and regulation of complex systems and critical infrastructures (e.g., aerospace, nuclear, chemical, energy generation and distribution, etc.).
Composition of the research group	2 Full Professors 1 Associated Professors 1 Assistant Professors 12 PhD Students
Name of the research directors	Enrico Zio

Contacts
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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	700.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Educational activities:Financial aid per PhD student is available for purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences, instrumentations and computer, etc. This amount is equal to 10% of the annual gross amount, for 3 years. ***Teaching assistantship:***Availability of funding in recognition of supporting teaching activities by

the PhD student. There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.
Joint/Double PhD program: possibility of a Double/Joint PhD program between Politecnico di Milano and MINES Paris-PSL University (France)

Computer availability: individual use.*Desk availability:* individual use.