POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 37th cycle

Research Area n. 1 - Advanced Materials and Smart Structures

THEMATIC Research Field: DIGITAL-TWIN AND ARTIFICIAL INTELLIGENCE APPLICATIONS FOR SPACE EXPLORATION PLATFORMS

Monthly net income of PhDscholarship (max 36 months)
€ 1325.0 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	The research is focused on the development and use of a Digital-Twin of the space exploration systems, based on numerical and analytical models, which allows the implementation of effective and cost-effective Health and Usage Monitoring Systems (HUMS) approaches. The proposed technological solution will integrate the combined use of real / virtual sensors and a virtual model of the main subsystems and their possible interconnections, both in normal conditions and in the presence of damage, in such a way as to constantly have an assessment of the expected behavior of the intact system and be able to "compare" it in real time with what is instead observed by the sensors, in order to identify any possible anomaly. This approach was developed as part of previous research projects in the European Defense Agency framework (HECTOR, ASTYANAX and SAMAS) and adapted to multiple case studies for (i) load monitoring, (ii) diagnosis of structural damage and anomalies system, (iii) the filtering of signals in real time for the identification and updating of the model parameters and (iv) the consequent prognosis of evolution of the damage or of the damaged system.Within the proposed project, statistical methods of advanced signal analysis and machine learning will be used for the identification and classification of damage and, using

	analytical or numerical damage evolution models, it will also be possible to predict the residual useful life of each subsystem, thus having the possibility to intervene promptly with the most suitable countermeasures.
Methods and techniques that will be developed and used to carry out the research	The Ph.D. candidate will first develop models (in the form of a Digital-Twin) of the systems under analysis. The Digital-Twin will be based either on Finite Element models or on analytical/empirical models, where the presence of the damage is considered in the model to simulate the behaviour of the structure in more realistic operative conditions.The Digital-Twin will then be used for the optimization of SHMP algorithms, specifically leveraging on machine learninig techniques, such as, but not limited to: • Physics informed neural networks • Transfer learning Methods are related to boost the capability of creating a multidisciplinary, multiphysics virtual environment aimed to define: • Numerical methods • Analytical and semi-analytical approaches • Experimental validation
Educational objectives	We provide doctoral candidates with high-level scientific training, fostering and refining research and problem-solving abilities. At the end of the PhD cycle the candidate will be able to plan and carry out original research by working in a team or leading a research group active in the field of structural health monitoring and prognosis. The candidate will strongly enhance both theoretical and experimental skills acquired during master studies. Opportunities will be offered for spending visiting periods hosted by project partners for scientific cooperation. Specifically concerning the HUMS field of application, the candidate will get command in the disciplines of: • HUMS system optimisation • Performance assessment • Sensor installation, acquisition and data processing

	• Machine learning algorithms • Bayesian model identification and updating • Methods for diagnosis and prognosis of systems under degradation • System model development (digital twin)
Job opportunities	A recent survey showed that PhD candidates are **100% employed** after one year, in national and international companies and academic and non-academic research institutions, engaged in innovation, research and technical development. On average the survey showed that people earning our PhD title obtain **35% higher salary** than the corresponding employers with a Master of Science degree. Specifically, the skills and know-how developed during the PhD will allow to cover positions for design, maintenance and integrity assessment of advanced systems and components in aerospace, automotive and mechanical companies.
Composition of the research group	1 Full Professors 3 Associated Professors 0 Assistant Professors 9 PhD Students
Name of the research directors	Proff. Claudio Sbarufatti, Marco Giglio

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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	564.01 €
By number of months	6

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

Funding for educational activities (purchase of study books and material, funding for participation in courses, summer schools, workshops and conferences); funding per PhD student per year:
2nd year: per student 1.534 euros
3rd year: per student 1.534 euros

Teaching assistantship: availability of funding in recognition of support to 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.

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

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