POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

THEMATIC Research Field: ALGORITHMS, STATISTICAL METHODS AND DIGITAL TWINS FOR THE DEVELOPMENT OF SMART MONITORING SYSTEMS

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	The research is focused on the development and use of methods toward the implementation of a Digital-Twin for the monitoring of industrial systems, based on numerical and analytical models, which allows the implementation of effective and cost-effective Health and Usage Monitoring Systems (HUMS). 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 artificial intelligence will be used for the identification and classification of damage, for load/overload monitoring, manoeuvre recognition 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 system's and structure's health monitoring algorithms, specifically leveraging on machine learning 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 1 Assistant Professors 9 PhD Students
Name of the research directors	Prof. Claudio Sbarufatti

Contacts
Prof. Claudio Sbarufatti *Phone:* +39 02 2399 8213   *Email:* claudio.sbarufatti@polimi.it Prof. Marco Giglio *Phone:* +39 022399 8234   *Email:* marco.giglio@polimi.it   For questions about scholarship/support, please contact phd-dmec@polimi.it.

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

POLITECNICO DI MILANO

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707,13. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month- net amount). Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. 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.