POLITECNICO DI MILANO

PhD in MATHEMATICS AND ITS APPLICATIONS - 42nd cycle

THEMATIC Research Field: PHYSICS-INFORMED GRAPH ML FOR REAL-TIME SATELLITE FAULT DETECTION AND CONTROL WITH LIMITED TELEMETRY DATA

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	Current space missions remain strongly dependent on ground-based infrastructure, relying on high-volume data downlinks and human intervention for anomaly detection and decision-making. This PhD research addresses this limitation by developing Scientific Machine Learning (SciML) models for on-board deployment. By processing telemetry on-site through physics-informed models, the project aims to enhance the operational autonomy of satellites. Eliminating latency due to data transmission enables onboard subsystems equipped with SciML models to sense, diagnose, and correct in real-time. Such capabilities are pivotal in high-risk or communication-constrained scenarios. The proposed research also enables next generation mission concepts, such as deep-space exploration, lunar far-side operations, or autonomous swarms in complex orbits. The project aims to design modular numerical frameworks capable of efficiently simulating satellite subsystems while assimilating telemetry data. Expected outcomes include the deployment of models for real-time monitoring, fault detection, and control applications. The PhD research activity will be carried out within a multidisciplinary collaboration between the MOX laboratory of the Department of Mathematics at Politecnico di Milano,the company Thales Alenia Space Italia S.p.A. (TAS-I) and the European Space Agency (ESA). This activity is co-funded by ESA and TAS-I under a grant obtained following the selection of an idea

	submitted to the Open Discovery Ideas Channel of ESA's Open Space Innovation Platform.
Methods and techniques that will be developed and used to carry out the research	The PhD research will focus on the development of innovative scientific machine learning approaches that leverage physical knowledge to cope with the limited sensors' information. Building on multiscale differential models and machine learning methods, the candidate will develop novel hybrid physics-based and data-driven architectures capable of handling the multiscale complexities of satellite subsystems in a modular manner. This framework will enable the construction of robust and interpretable models that support decision-making through real-time fault detection and optimal control. The approach will be validated on satellite subsystems using real telemetry data on selected ESA and TAS-I satellite platforms.
Educational objectives	The PhD student will develop advanced competencies in the field of mathematical and numerical modeling for complex space applications by working within a multidisciplinary group.Internships at ESA and TAS-I are planned, enabling the student to validate the developed approaches directly on satellite platforms.
Job opportunities	Graduates of this program are in high demand across various research institutions, industries, and tech-driven sectors. Their versatile modeling and numerical skills provide access to excellent opportunities, including private research and innovation industrial consulting, scientific software development and risk assessment in management and insurance. In the academic sector, graduates of this program are prepared for postdoctoral positions, tenure-track faculty roles, and research fellowships in international institutions and universities.
Composition of the research group	5 Full Professors 14 Associated Professors 3 Assistant Professors 0 PhD Students
Name of the research directors	Proff. S. Pagani e N. Parolini

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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

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
The PhD student is provided with a personal workstation and access to shared computing facilities. The PhD student has access to office space, university libraries, and a wide range of online scientific resources. The student will benefit from access to high-performance computing infrastructure.Financial support is available each year to cover expenses related to training activities and participation in courses, summer schools, workshops and conferences. Financial aid per PhD student per year: 1st year: max 1.902,40 euros 2nd year: max 1.902,40 euros 3rd year: max 1.902,40 euros The PhD student is encouraged to take part in activities related to teaching, within the limits allowed by the regulations. The PhD student can benefit from the international dimension of the ESA's Open Space Innovation Platform, which involves close interaction with the research teams of the project partners (ESA and TASI).