POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: DEVELOPMENT OF COOPERATIVE ADAS BASED ON DYNAMIC DRIVING SIMULATOR TESTS

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	Driving simulators are extensively used by car manufacturers and OEMs to develop products while reducing the costs and risks associated with outdoor tests. The DriSMi Lab of Politecnico di Milano (https://www.drismi.polimi.it/) hosts an innovative dynamic driving simulator, where the cockpit of a commercial car moves throughout a 6x6-meter platform thanks to a system of cables and electric actuators. The dimensions of the simulator allow to reproduce maneuvers like lane-change in 1:1 scale. Through its innovative features, the simulator provides an immersive and realistic test environment that can be safely experienced also by non-professional drivers. This last opportunity appears nowadays of particular interest as new ADAS (Advanced Driver-Assistance Systems) systems or control logics for CCAM (Cooperative, connected and automated mobility) vehicles can be developed also considering the feedback from common users. The final costumer can thus influence the development of such systems so that they can be tailored on specific profiles to improve their acceptance.
Methods and techniques that will be developed and used to carry out the research	The dynamic simulator is a sophisticated system resulting from the integration of mechanics, electronics, control systems, computer vision and real-time applications. It is essential to develop interdisciplinary skills that include multi-body system dynamics, non-linear systems, control systems, real-time applications, vehicle dynamics, tire-

	systems, real-time applications, vehicle dynamics, tire-road interaction models, powertrain and brake system models, vibration control, acoustics.
Educational objectives	The challenges that the candidate will have to face are both theoretical and experimental: •develop hi-fi models for components like tires (including surface temperature effect, interaction with wet surfaces), suspensions, engine/powertrain, brakes, actuators, sensors like lidars, cameras; •develop innovative ADAS possibly based on a sensor-fusion approach that are able to exploit V2X communication. •develop control algorithms for automated driving possibly based on a sensor-fusion approach that are able to exploit V2X communication •objectively evaluate drivers' reactions and upgrade/tailor the settings of the control systems accordingly
Job opportunities	Being the research carried out with the state-of-the-art of driving dynamic simulators, the primary job opportunity will be in the automotive field. Automobile industries and companies providing components (brake systems, suspensions, powertrain).Besides this, job opportunities will be with national and international academic and non-academic institutions and organizations, engaged in innovation, research and technical development. Our last survey on MeccPhD Doctorates highlighteda 100% employment rate within the first year and a 35%higher salary, compared Master of Science holders in thesame field.
Composition of the research group	1 Full Professors 1 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	Proff. Edoardo Sabbioni, Stefano Melzi

Contacts
Email: edoardo.sabbioni@polimi.it , stefano.melzi@polimi.it For questions about scholarship/support 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	750.0 €
By number of months	6

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 6.114,50.
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. 750 euro/month- net amount).
Teaching assistantship: availability of funding in recognition of supporting teaching activitiesby 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: ACTIVE PANTOGRAPH AND NEW METHODOLOGIES FOR PANTOGRAPH LAB TESTING AND VALIDATION

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	Pantograph-catenary interaction is one of the limiting factors for interoperability among different countries and for the speed-up of railway systems. The introduction of active pantograph control is considered as a possible source of improvement, giving the possibility to improve/optimise the dynamic interaction in different operating conditions. On the other hand the field testing of existing or new pantograph (passive or active) is usually costly and time consuming, therefore there is a strong interest by manufacturers and railway operators to reduce the filed tests and perform at least part of the pantograph acceptance and homologation to laboratory tests or simulation with validated.
Methods and techniques that will be developed and used to carry out the research	The research will focus on the development of active solutions for the optimization of pantograph dynamics and of new methodologies for laboratory testing, for both active and passive pantograph. Numerical tools will be adopted for preliminary design and evaluation of the pantograph active system. An active pantograph prototype will then be realized and tested. Considering laboratory testing, both Hardware-in-the-Loop methodologies and identification/validation techniques based on imposed and fixed excitation will be developed and exploited.
Educational objectives	The candidate will acquire high-profile skills and will be

	dealing with both theoretical and experimental methodologies. He/she will develop knowledge in the following areas: - analysis of complex dynamic systems with different methods and approach (numerical simulation, co-simulation of interacting virtual and physical components, experimental identification and validation) - analysis and optimisation of the performance of complex systems - technology and innovation in pantograph design and testing Finally, the candidate will gain the capability of working and cooperating in a multidisciplinary team.
Job opportunities	Job opportunities may be found as: pantograph manufacturers, rail vehicle manufacturers, rail transport operators, railway infrastructure managers. Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/. The following Universities and companies will be cooperating in the research activity: University of Huddersfield, Universitat Politècnica de València, Contact, Hitachi Rail, Trenitalia, RFI.
Composition of the research group	2 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Alan Facchinetti

Contacts
Phone: +39 02 2399 8450 *Email:* alan.facchinetti@polimi.it For further information/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	750.0 €
By number of months	6

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 6.114,50.

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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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PARTENARIATO PNRR Research Field: HOMOLOGATION OF AUTONOMOUS VEHICLES THROUGH CAUSAL INFERENCE TECHNIQUES

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	One of the primary challenges in achieving effective implementation of autonomous driving is to provide efficient, fast, and cost-effective tools for validating the developed systems. It is worth mentioning that even a modification of a control parameter necessitates re-approval of the entire system. Particularly, the extensive number of simulation tests and subsequent experimental tests required impede the swift deployment of such systems. In light of this, our project aims to develop a methodology based on statistical analysis tools to minimize the reliance on simulations and the need for physical prototype testing. In detail, the utilization of causal inference is deemed essential as it enables us to understand the cause-effect relationships among the variables involved. This understanding assists in identifying the direct and indirect influences of various factors on the effectiveness of the driving system, thereby enhancing the ability to predict and manage complex situations safely and efficiently. The project encompasses two main phases: the initial creation of a simulation tool for the vehicle-control-environment system through experimental test data to establish a digital twin, and the subsequent development of statistical methodologies to reduce the significant number of tests required for validating the examined system. Finally, the developed methodology will be applied to diverse working conditions (vehicle-control-environment) to assess its generality.

	The research activity is financed and developed within the Sustainable Mobility Center (Centro Nazionale per la Mobilità Sostenibile - CN - MS) - Spoke 6 (Connected and autonomous vehicle - Guida autonoma e veicolo connesso) CN00000023, as part of the National Plan for Recovery and Resilience (PNRR, M4 C2 Dalla Ricerca all'impresa, Investimento 1.4), finanziato dall'Unione Europea - Next GenerationEU. Norms of reference: CUP D43C22001180001 - D.D. 1033 del 17/06/2022; D. D. 3138 del 16/12/2021 rettificato con D.D. 3175 del 18/12/2021 Avviso pubblico per presentazione Proposte di intervento per il Potenziamento di strutture di ricerca e creazione di "campioni nazionali" di R&S su alcune Key Enabling Technologies da finanziare nell'ambito del Piano Nazionale di Ripresa e Resilienza, Missione 4, Componente 2, Investimento 1.4 "Potenziamento strutture di ricerca e creazione di "campioni nazionali di R&S" su alcune Key Enabling Technologies" finanziato dall'Unione Europea - Next GenerationEU.
Methods and techniques that will be developed and used to carry out the research	To carry out the research, various methods and techniques will be developed and utilized. Statistical analysis tools, particularly causal inference, will be employed to understand cause-effect relationships among system variables. This will help in predicting and managing complex situations efficiently. The project will start with the creation of a simulation tool using experimental test data to establish a digital twin of the vehicle-control-environment system. Subsequently, statistical methodologies will be developed to minimize the need for extensive simulation and physical prototype testing, thereby reducing the overall number of tests required for system validation. The methodology will then be applied to different working conditions to assess its general applicability.
Educational objectives	The PhD candidate will: •develop a proficiency in statistical analysis tools and methodologies, particularly causal inference; •gain hands-on experience in developing simulation tools and establishing digital twins of vehicle-control-

	environment systems; •enhance his/her ability to develop and apply statistical methodologies to minimize the need for extensive testing in system validation.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared MSc holders in the same field. These job opportunities span various disciplines such as engineering, sustainability, material science, and project management, offering diverse career paths for individuals interested in advancing sustainable practices in the field of electric vehicle technology. Some partner universities are: Scuola Superiore Sant'Anna - Italy, and ETH Zurich - Switzerland.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Francesco Braghin

Contacts
Phone: 02 2399 8306 *Email*: francesco.braghin@polimi.it, marta.gandolla@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	750.0 €
By number of months	6

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 6.114,50. 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. 750 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PARTENARIATO PNRR Research Field: UNMANNED VEHICLES FOR AGRICULTURAL APPLICATIONS

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	Automation plays a crucial role in the agricultural sector, revolutionizing traditional farming practices. It offers numerous benefits, enhancing efficiency, productivity, and sustainability. Automated systems streamline tasks such as planting, irrigation, and harvesting, reducing manual labor and costs. This technology enables precise control over processes, optimizing resource utilization and minimizing waste. Furthermore, automation facilitates the adoption of innovative techniques like vertical farming and hydroponics, enabling year-round production and mitigating environmental impact. The research objective is to develop autonomous guidance systems for agricultural applications, addressing the challenges unique to this field. The primary focus lies in tackling the complex environment interaction, which differs from that of a typical road vehicles. Vehicle dynamics and sensor measurements are heavily influenced by the terrain, necessitating specific control systems that account for mechanical and geometric constraints of the involved vehicles. Additionally, the research will explore various agricultural applications that differ in their processing objectives and the different modes of interaction with the environment and human operators. The aim is to overcome these obstacles and create robust autonomous systems tailored to the agricultural setting. The research activity is financed and developed within the Sustainable Mobility Center (Centro Nazionale per la

	Mobilità Sostenibile - CN - MS) - Spoke 6 (Connected and autonomous vehicle - Guida autonoma e veicolo connesso) CN00000023, as part of the National Plan for Recovery and Resilience (PNRR, M4 C2 Dalla Ricerca all'impresa, Investimento 1.4), finanziato dall'Unione Europea - Next GenerationEU. Norms of reference: CUP D43C22001180001 - D.D. 1033 del 17/06/2022; D. D. 3138 del 16/12/2021 rettificato con D.D. 3175 del 18/12/2021 Avviso pubblico per presentazione Proposte di intervento per il Potenziamento di strutture di ricerca e creazione di "campioni nazionali" di R&S su alcune Key Enabling Technologies da finanziare nell'ambito del Piano Nazionale di Ripresa e Resilienza, Missione 4, Componente 2, Investimento 1.4 "Potenziamento strutture di ricerca e creazione di "campioni nazionali di R&S" su alcune Key Enabling Technologies" finanziato dall'Unione Europea - Next GenerationEU.
Methods and techniques that will be developed and used to carry out the research	The research will be carried firstly in simulation (using specific simulation software) and part of the developed algorithms will be verified and evaluated by means of experimental campaigns. Data analysis from sensors will be performed both for state estimation and for environment reconstruction by means of sensor fusion and ML techniques. Optimal control techniques as well as data driven approaches will be evaluated. Matlab/Python/C++ will be considered in the development of the different algorithms.
Educational objectives	The PhD student will gain and interdisciplinary knowledge of technologies and processes related to autonomous vehicles: from vehicle dynamics, to control in presence of significant delays, and to communication protocols.
Job opportunities	Skills and competences in the field are extremely interesting for all the companies involved in automotive industry. Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared to Master of Science holders in the same field.

Composition of the research group	1 Full Professors 0 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Francesco Braghin

Contacts
The research project will be carried out in the Department of Mechanical Engineering, Politecnico di Milano. *E-mail*: francesco.braghin@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	750.0 €
By number of months	6

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 6.114,50. 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. 750 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

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

INTERDISCIPLINARY Research Field: OUTDOOR DYNAMIC MONITORING SYSTEM FOR MOTION TRACKING IN SPORT

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	Interdisciplinary PhD Grant The PhD research will be carried out in collaboration with research groups of the PhD programme in "**INFORMATION TECHNOLOGY**". See https://www.dottorato.polimi.it/?id=422&L=1 for further information. In competitive sports, optimizing athletic movements to maximize performance is crucial. In this context, the use of monitoring technologies, such as marker-based video systems or IMUs, is key to studying and optimizing movement. However, these systems can only be used in closed environments and limited spaces or require athletes to wear devices that make movements less natural and impractical for use in competitions. For monitoring and optimizing outdoor sports that take place in large spaces (such as skiing or rowing), non-intrusive measurement systems are currently unavailable. This project aims to develop and test a mobile technology, initially based on drones and computer vision, capable of: i) tracking athletes in extensive and dynamic environments; ii) monitoring movements without interfering with the athlete to identify and track the position of the body's joints and reconstruct their 3D shape from image sequences;and iii)providing coaches and technicians with accurate information on athletic movements to improve performance.

Methods and techniques that will be developed and used to carry out the research	The research will involve developing and utilizing several methods and techniques. These include creating a mobile flying technology with measurement instruments for outdoor athlete monitoring, devising image analysis algorithms for athlete tracking and monitoring of kinematic and biomechanical variables, analyzing obtained data to provide athletes with accurate feedback on their motor gestures, and integrating control and tracking skills for mobile technology with advanced machine learning techniques for data extraction from video streaming.
Educational objectives	The main educational objectives of the research project are: •enhancing students' proficiency in developing and implementing advanced technologies for athlete monitoring and performance optimization; •fostering skills in image analysis algorithms and data processing techniques for tracking and monitoring athlete movements; •providing hands-on experience in integrating various measurement instruments and technologies into a mobile flying platform for outdoor athlete monitoring.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared MSc holders in the same field. These job opportunities span various disciplines such as engineering, sustainability, materials science, and project management, offering diverse career paths for individuals interested in advancing sustainable practices in the field of electric vehicle technology. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: Technical University of Munich (TUM) - Germany; University of Oxford - UK; ETH Zurich - Switzerland.

Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Proff. Francesco Braghin, Giacomo Boracchi

Contacts
Phone: 02 2399 8306 Email: francesco.braghin@polimi.it For questions about scholarship/support: 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	750.0 €
By number of months	6

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, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of € 5.707,13. Our candidates are strongly encouraged to spend a research period abroad, joining high-levelresearch 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 activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: NONLINEAR HYBRID EXPERIMENTAL-NUMERICAL REDUCED ORDER MODELS FOR CALIBRATION AND AND REAL-TIME MONITORING OF MEMS DEVICES

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	MEMS (Micro Electro-Mechanical Systems) industry has played a significant role in technological advancements across various domains over the past few decades. In fact, these devices, including microphones, PMUT, accelerometers, and gyroscopes, have become integral components of smartphones, computers, and vehicles. The demand for such devices continues to grow, driving the need for higher performance and smaller sizes.However, as the size of MEMS devices decreases, their dynamic response and performance are affected. The motion becomes relatively larger compared to the device's characteristic dimensions. Consequently, the assumption of small deformations no longer holds, leading to the occurrence of nonlinear dynamic phenomena. Additionally, fringing field effects of electrostatic actuation and fluid-structure interaction become significant factors.This research aims to develop experimental methods to characterize the response of MEMS devices and utilize the resulting data to create hybrid experimental-numerical models with predictive capabilities. These models will be instrumental for the calibration and real-time monitoring of MEMS devices.
Methods and techniques that will be developed and used to carry out the research	The candidate will have to get familiar with multi-physics nonlinear dynamics, including classical softening/hardening behavior and more complex

	phenomena such as sub/super-harmonics, parametric resonances, internal resonances, and isolated and quasi-periodic responses, both from an analytical and a numerical point of view.Subsequently, the candidate will carry out experimental tests on MEMS devices (e.g. gyroscope prototypes) provided by STMicroelectronics. Advanced experimental techniques, among which the Control Based Continuation strategy (CBC), will be implemented. This strategy involves using a phase controller (e.g., Phase Locked Loop, PLL) to track the system's resonance.Additionally, the candidate will explore recent regression strategies based on ringdown experiments to develop a data-driven Reduced Order Model (ROM).Finally, the candidate will integrate the advanced experimental techniques and the data-driven ROM to leverage the ROM for increased robustness and noise rejection (similar to a Kalman filter approach), while the ROM will be continually updated using the data provided by advanced experimental techniques.This procedure has potential applications in calibrating mass-produced MEMS devices and providing custom-tailored ROMs for each device. These ROMs can be hosted onboard the device, enabling various functionalities such as filtering, performance degradation monitoring, and fault detection.
Educational objectives	The PhD candidate is expected to develop a solid competence in MEMS technology, MEMS-oriented experimental procedures, dedicated laboratory equipment, and experiment automation in LabVIEW. Moreover, the candidate will acquire a strong knowledge of nonlinear dynamics and related phenomena.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: STMicroelectronics; Delft Institute of Technology; ETH Zurich.

POLITECNICO DI MILANO

Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Proff. Francesco Braghin, Jacopo Marconi

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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

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, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of € 5.707,13. Our candidates are strongly encouraged to spend a research period abroad, joining high-levelresearch 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 activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: META-MEMS-BASED NEURAL NETWORKS

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	Taking advantage of the advancements in both the fields of Micro Electro-Mechanical Systems (MEMS) and deep learning algorithms, this PhD aims to develop a novel MEMS device that can process mechanical signals using mechanical components, i.e. to simulate the behavior of an artificial neural network (ANN) without the traditional digital operations, offering a new approach to signal processing within MEMS devices. The advantage of exploring mechanical artificial neural networks (ANNs) over their software-based counterparts has some key advantages: •efficiency: mechanical ANNs eliminate the need for digital operations by using physical systems, resulting in more energy-efficient processing and reducing the energy consumption associated with running complex algorithms in software; •parallel processing: compared to software ANNs that typically rely on sequential data processing, mechanical ANNs can process signals in parallel thus leading to faster and simultaneous processing of multiple inputs; •robustness: by employing robust physical elements in the form of interconnected mechanical resonators, mechanical ANNs may offer increased resilience to noise, interference, and other external environmental factors.

	The objective of this PhD is, therefore, to integrate deep learning algorithms and metamaterials to design novel MEMS devices that can perform complex signal processing tasks solely through mechanical components, mimicking the functionality of an ANN and without the requirement for external computational resources.
Methods and techniques that will be developed and used to carry out the research	The candidate will formulate and develop mathematical models to study interconnected metamaterial architectures, understanding the principles behind their (eventuaYy nonlinear) dynamic behavior, and predicting their performance characteristics. This task will be carried out both analytically and numerically using computer simulations and computational tools to simulate different configurations, and validate theoretical predictions. Software tools, such as finite element analysis (FEA) or computational fluid dynamics (CFD), will be employed for this purpose.Relevant case studies are the implementation of transfer functions to achieve desired output responses from given input signals. Optimizing and fine-tuning the designed mechanical ANN is also a target of this PhD and will require dedicated algorithms.Once a solution for a dedicated mechanical ANN is found, experiments will be carried out to validate and calibrate the theoretical models and numerical simulations, testing the performance of the designed network in real-world conditions and comparing the results with the expected outcomes.
Educational objectives	This PhD will allow the candidate to gain deep knowledge and comprehension of metamaterial architectures, their properties, characteristics, and applications in advanced technology and signal processing. Moreover, the candidate will develop expertise in formulating and solving mathematical models that describe the behavior and interactions within interconnected metamaterial networks, enabling accurate predictions and informed design decisions. Additionally, the candidate will acquire skills in using computational tools and software for simulating the behavior of complex systems, verifying theoretical predictions, validating experimental results, and optimizing the performance of metamaterial structures

	through virtual experiments. Finally, the candidate will gain hands-on experience in designing and conducting experiments to validate theoretical models and numerical simulations, assess the functionality of metamaterial networks, and collect data for analysis and interpretation.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. List of Universities, Companies, Agencies and/or National or International Institutions that are cooperating in the research include: STMicroelectronics; University of California San Diego; Delft Institute of Technology; ETH Zurich.
Composition of the research group	1 Full Professors 0 Associated Professors 2 Assistant Professors 2 PhD Students
Name of the research directors	Proff. F. Braghin, J. Marconi, E. Riva

Contacts
Phone: +39 02 2399 8306 Email: francesco.braghin@polimi.it; jacopo.marconi@polimi.it; emanuele.riva@polimi.it For questions about scholarship/support: 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	750.0 €
By number of months	6

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

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: NONLINEAR AND MULTI-PHYSICAL PARAMETRIC AND TOPOLOGICAL OPTIMIZATION OF MEMS DEVICES

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	MEMS (Micro Electro-Mechanical Systems) industry has experienced significant growth in recent decades. Devices like microphones, PMUT, accelerometers, and gyroscopes have found applications in diverse areas such as smartphones, computers, and vehicles. The demand for these devices continues to rise, with increasing performance requirements and the need for smaller sizes.However, the current approach to MEMS design relies heavily on engineers' trial-and-error experience. This approach has several drawbacks: (i) it is user-dependent, (ii) it is time-consuming, and (iii) it primarily focuses on linear structural analysis, neglecting nonlinear dynamic phenomena and multi-physical effects like electrostatics and damping from fluid-structure interaction.In this research project, the goal is to develop an optimization framework for the design of MEMS devices. This framework will utilize parametric and topology optimization techniques and consider multiple physical domains. By adopting this approach, we aim to overcome the limitations of the traditional design process and achieve more efficient and optimized MEMS device design.
Methods and techniques that will be developed and used to carry out the research	The candidate will start the research by delving into parametric optimization, where the structure's topology is predetermined, and dimensions such as beam lengths and widths need to be determined based on some performance index. This phase will serve as an ideal

	performance index. This phase will serve as an ideal testing ground for developing and validating multi-physical models, e.g. encompassing mechanics and electrostatics, as well as nonlinear dynamical models utilizing reduced order models (ROMs). Drawing upon existing studies and software from our group, the candidate will devise strategies and codes to tackle the aforementioned challenges effectively.Then, the candidate will study topology optimization, where the structural shape isn't known beforehand but rather emerges from a solid block through “carving”. Special focus will be placed on density-based and level-set approaches, with an emphasis on the latter due to its notable advantages. Our group's recent efforts revolve around this method, collaborating with international partners to co-develop a dedicated software. The candidate will have the opportunity to develop new routines and features to address multi-physics problems and practical tools, including minimum and maximum dimension control.Finally, the optimization efforts will be focused towards individual component optimization, encompassing areas such as elastic suspensions and actuating electrode shape, as well as towards the optimization of complete systems, like accelerometers provided by our industrial partner, STMicroelectronics.Based on the outcome of the previous steps, a MEMS prototype will be produced and tested in our laboratory to validate the proposed methods.
Educational objectives	The PhD candidate is expected to develop a solid competence in optimization procedures for dynamical problems, and in particular on level-set approach. The candidate is also expected to acquire competencies in nonlinear dynamics, multi-physical modelling, and MEMS technology. Contextually, strong coding skills in Matlab/Python/C++ will be gained.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared Master of Science holders in the same field. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in

	the research include: STMicroelectronics; University of California San Diego; Delft Institute of Technology; ETH Zurich.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Proff. Francesco Braghin, Jacopo Marconi

Contacts
Email: francesco.braghin@polimi.it; jacopo.marconi@polimi.it. For questions about scholarship/support: 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	750.0 €
By number of months	6

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, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of € 5.707,13. Our candidates are strongly encouraged to spend a research period abroad, joining high-levelresearch 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 activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 629 PA Research Field: SUSTAINABLE TRANSPORT INFRASTRUCTURE

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	This research addresses the challenges that public administrations face to address investment in transport infrastructure toward sustainable mobility.The PhD will contribute to renew competences and instruments with the final goal to improve public administration governance and management capacities in relation to the assessment of transport schemes.In the transport sector, several strategies have been adopted to bridge up accessibility gaps es, as well as funding programmes to rebalance by means of infrastructure investments social disparities (e.g. core-periphery; rural vs. urban areas) and to assess the economic, environmental and social impacts of investments in transport sector.The above-mentioned policies need to be carefully assessed and duly planned, in order to facilitate an effective transition without inefficiencies and other undesirable indirect counter-effects.This research programme aims at developing an overall framework to assess transport infrastructure and the impacts of investments in transport technologies at the regional scale, contextualizing them in the context of Lombardy Region. Starting from the regional policy and administrative framework, including funding for Rail and Road networks development as well as mass rapid transport and fleets renewal, the research would allow to upgrade the current technical guidelines in order to improve the public administrations capacity to address public spending towards more equitable and effective decision-making.

Methods and techniques that will be developed and used to carry out the research	The research will be conducted in collaboration with the Directorate General on Infrastructure of the Lombardy Region (Italy). To carry out this research the following methods and techniques will be developed: - traffic assignment models (micro and macro), in order to forecast traffic flows and congestion on the transport networks; - cost-benefit and multi-criteria analyses, in order to compare methods for assessing impacts of infrastructure investments; - advanced discrete choice models, in order to simulate travellers' behaviour, attitudes and perceptions about innovative technologies and new modes of transport.
Educational objectives	The project will provide candidate with: - knowledge of the transportation sector, particularly the impact assessment of new (rail and road) infrastructure; - methodological competences at both the theoretical and applied level; - problem setting and solving capabilities; - capabilities to interact with people o diverse background.
Job opportunities	Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 4 PhD Students
Name of the research directors	Prof. Pierluigi Coppola

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Email: Pierluigi.coppola@polimi.it Ph +39 02 2399 8376 https://www.mecc.polimi.it/ricerca/personale-docente/personale-docente/prof-pierluigi-coppola For questions regarding 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	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)	Regione Lombardia
By number of months at the company	12
Institution or company where the candidate will spend the period abroad (name and brief description)	Università della Cantabria (Santander, ES)
By number of months abroad	6

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 6.114,50.
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 theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 630 Research Field: VIBRATION CONTROL IN SATELLITE ANTENNAS THROUGH PASSIVE AND ACTIVE METAMATERIALS

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	Metamaterials are periodic structures composed of repeating unitary elements that form a lattice configuration. This unique arrangement provides the structure with reduced mass and inherent filtering capabilities for elastic waves and vibrations within specific frequency ranges, known as bandgaps. Consequently, metamaterials offer a promising solution for addressing vibration challenges in satellite antennas, especially during launch phases when antennas are stowed. This stowed configuration necessitates decoupling the antenna's resonances from those of the satellite, typically achieved through mechanisms such as Hold-down and Release Mechanisms (HRM). In missions like Mars Ice Mapper, HRMs, particularly Primary HRMs (PHRM), are crucial for maintaining structural integrity. Introducing metamaterials at the interfaces between these HRMs and the satellite panel, as well as at the bracket of the deployment mechanism, could potentially mitigate the vibrations transmitted to the antenna during launch. These efforts aim to enhance the antenna's structural stability, reduce mass margins, and lower vibration levels.Even after deployment, micro-vibrations originating from satellite attitude control mechanisms, such as thrusters, present additional challenges. To maintain stable antenna performance, especially for missions involving optical instruments, minimizing micro-vibrations is paramount. Innovative brackets capable of attenuating such vibrations, through passive or active control, would

	significantly benefit missions with optical instruments dependent on adjustable antennas.During this PhD project, the candidate will develop passive and active metamaterial solutions to suppress vibrations within specific frequency ranges, while adhering to mass constraints and addressing the challenges posed by the space mission. In addition to vibration mitigation, the research will consider buckling and snap-through phenomena, tensegrity, and deployable mechanisms to control motion, deformation, and energy dissipation in these structures.
Methods and techniques that will be developed and used to carry out the research	The candidate will develop advanced optimization methods tailored for metamaterial design. This will include adapting techniques such as topology optimization and PDE-constrained optimization to meet the specific requirements of space missions and to accommodate desired multiphysics interactions, control schemes, and nonlinear dynamics.In addition, theoretical and numerical methods will be developed to investigate the role of tensegrity and deployability in metamaterials, where large motions and deformations are integrated with vibration control challenges. Particular emphasis will be placed on how these mechanisms can control motion, deformation, and energy dissipation, thereby enhancing the adaptability and robustness of the metamaterials. The process will involve numerical modeling and optimization, followed by prototyping and experimental testing of the metamaterials in a laboratory environment. These tests will replicate the dynamic excitations experienced under real-world conditions, ensuring the practical viability and effectiveness of the developed metamaterials.
Educational objectives	The PhD candidate is expected to develop a solid competence in structural dynamics, metamaterials and space engineering. The candidate is also expected to acquire (at least) the rudiments of multi-physics modeling and strong coding skills in Matlab/Python/C++.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared to Master of Science holders in

	the same field. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: Thales Alenia Space, Georgia Tech, University of Colorado Boulder, Imperial College, ETH Zurich.
Composition of the research group	1 Full Professors 0 Associated Professors 2 Assistant Professors 1 PhD Students
Name of the research directors	Proff. Francesco Braghin, Emanuele Riva

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	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)	Thales Alenia Space Italia (Rome)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Georgia Institute of Technology (USA)
By number of months abroad	6

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 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-levelresearch 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. 750 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 630 Research Field: ACTIVE NOISE CONTROL AND SOUND QUALITY ENHANCEMENT WITHIN VEHICLE COMPARTMENTS

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	The advancement of technology in automotive has significantly enhanced driving experiences, yet the issue of cabin noise remains a persistent challenge. Interior noise, originating from powertrain, tires, and aerodynamic turbulence, can adversely affect passenger comfort, reduce speech intelligibility, and contribute to driver fatigue. Traditional passive noise control methods, such as insulation and damping materials, show their limitations in effectiveness and efficiency, especially at low-mid frequencies. Consequently, there is a compelling need to explore innovative solutions that can provide superior noise reduction without compromising vehicle weight or space.Active Noise Control (ANC) presents a promising alternative to conventional methods by utilizing destructive interference to cancel unwanted sound waves. The integration of ANC systems in vehicles aims to create a quieter and more pleasant cabin environment, enhancing overall passenger comfort and meeting the growing consumer demand for quieter vehicles. The primary objective of this research is to develop and optimize advanced ANC algorithms capable of real-time noise cancellation across a wide range of frequencies. These algorithms must be highly adaptable and robust to accommodate varying noise conditions and vehicle dynamics. Additionally, the research aims to integrate ANC systems within existing vehicle architectures, ensuring minimal impact on vehicle weight, power consumption and design.Another key objective is to

	conduct comprehensive assessments of ANC system performance in various driving conditions and environments. This includes measuring improvements in cabin noise levels, passenger comfort, and speech intelligibility. Investigating the psychological and physiological effects of reduced cabin noise on drivers and passengers is also essential to understand the overall impact on the driving experience and safety.Furthermore, the research explores the potential for ANC systems to reduce the need for heavy, resource-intensive soundproofing materials, thereby contributing to sustainability efforts. Evaluating the cost-benefit ratio of implementing ANC systems in mass-produced vehicles is crucial to determine their feasibility and economic viability. By addressing these objectives, this research aims to pioneer advancements in noise control within the vehicle compartment, contributing to the development of quieter, more comfortable and energy-efficient vehicles. The successful implementation of ANC technology could represent a new standard for in-cabin acoustic environments.
Methods and techniques that will be developed and used to carry out the research	This research is characterized by a strong interdisciplinary approach. To achieve the objectives of the research on active noise control (ANC) within vehicles, a comprehensive and systematic approach will be employed, utilizing the analytical, numerical, and experimental tools of PoliMi DMEC and the Polimi Sound and Vibration Laboratory (PSVL). The methods and techniques developed and employed will encompass several key areas, including algorithm development, system integration, performance evaluation, human factors analysis, and sustainability assessment. By employing these methods and techniques, the research aims to develop innovative and effective ANC solutions that significantly improve the acoustic environment within vehicles. The integration of cutting-edge technology, rigorous testing, and comprehensive evaluations will ensure that the resulting ANC systems meet the highest standards of performance, safety and sustainability.
Educational objectives	The candidate will acquire high-level skills and will work

	on one of the most significant and challenging problems in NVH engineering, addressing both theoretical and experimental methodologies. He/she will become an expert in Active Noise Control (ANC) modeling and experimental testing, including signal processing and system identification. The candidate is expected to provide original contributions to the development and experimental validation of innovative ANC tools.
Job opportunities	Future job opportunities primarily lie within the automotive sector, particularly in the NVH (Noise, Vibration, and Harshness) area, including R&D departments of automotive industries such as automobile manufacturers and suppliers of vehicle components. Additionally, opportunities exist in national and international academic and non-academic institutions and organizations engaged in innovation, research, and technical development. Furthermore, according to our latest survey of MeccPhD Doctorate, there is a 100% employment rate within the first year, with salaries being 35% higher compared to Master of Science holders in the same field. Employment statistics of PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/
Composition of the research group	1 Full Professors 1 Associated Professors 0 Assistant Professors 3 PhD Students
Name of the research directors	Prof. Francesco Ripamonti

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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)	Ferrari Spa
By number of months at the company	18
Institution or company where the candidate will spend the period abroad (name and brief description)	University of Southampton; RWTH Aachen University; Universitat Politècnica de València; Graz University of Technology; Silesian University of Technology
By number of months abroad	6

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, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of € 6.114, 50. Teaching assistantship: availability of funding in recognition of supporting teaching activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: DESIGN AND CONTROL OF AN EXTRANUMERARY LIMB FOR HUMAN-CENTRIC MANUFACTURING

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	Remanufacturing is the most valuable circular economy option, providing relevant economic returns to European manufacturing companies, contributing to the creation of knowledge-intensive jobs and new skills. However, modern high-added value consumer products manufactured in Europe are evolving into high-complexity smart products, embedding sensors and intelligence to provide an improved set of customized functions to users and to reduce the environmental footprint. This product transformation is posing additional burden on the implementation of safe, economically and environmentally attractive remanufacturing business cases aiming at reusing functions and materials from post-use high-added value products. The main objective of the remanufacturing process is to smooth the propagation of the product variability throughout the remanufacturing value-chain and factory stages. The quality requirements from the recovered parts are extremely demanding, since “as good as new” critical product characteristics have to be guaranteed. The regeneration rate in remanufacturing is usually between 50%-70%. The main limitations in the current remanufacturing practices include high-dependency on human activities with poor adoption of human-centered solutions. In spite of the massive dependency on human tasks, frequently complex, articulated and involving high loads, and knowledge-intensive decision making, specific technologies and tools in support of humans are poorly adopted in

	remanufacturing.The proposed research seeks to address these challenges by leveraging robotics and machine learning to enhance worker's safety and efficiency in disassembly processes, within the context of Industry 5.0.
Methods and techniques that will be developed and used to carry out the research	**Phase 1** The candidate will start the research by delving into robotics and machine learning algorithms. On the one side, currently developed robotic systems for disassembly will be analyzed, with particular focus on wearable and collaborative solutions. On the other hand, machine learning approaches for robotic task learning and generalization will be analyzed. This phase will serve as a first step to understanding what is already available in the considered domain before designing ad hoc methodologies. **Phase 2** Design and test of specific experimental protocols and metrics for ergonomic evaluation of workplaces and tasks, which could be used to identify critical situations to be specifically addressed (by wearable technologies, cobots or other solutions). The evaluation methodology will include a dedicated sensors network (i.e., evaluation toolkit): i) evaluation of the kinematic of the movement(s) by means of IMUs, ii) evaluation of muscular involvement, effort, and fatigue by means of EMG measurements; iii) evaluation of loads applied to most relevant joints by means of inverse dynamic calculation through simulation softwares (e.g., AnyBody); iv) evaluation of cognitive and systemic load by means of heart rate variability assessment. **Phase 3** Design, development and on-field test of wearable extranumerary limb to mitigate the impact of fatigue on effort, attention and/or concentration level of the workers. Supernumerary limb solutions are at state-of-the-art edge and consists in a combination of a mechanical design, a sensor net with motion intention decoding algorithms, and a shared controller, in an effort to seamlessly integrate the additional limb with the target activity. This research project is carried out as part of the Horizon

	Europe rEUman G.A. 101138930 project funded by the European Community with international academic and industrial partners.
Educational objectives	The PhD candidate is expected to develop solid competencies in robotics, mechatronics and machine learning. The candidate is also expected to acquire competencies in nonlinear dynamics, multi-physical modelling, and optimization algorithms. Contextually, strong coding skills in Matlab/Python/C++ will be gained.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared MSc holders in the same field. These job opportunities span various disciplines such as engineering, sustainability, material science, and project management, offering diverse career paths for individuals interested in advancing sustainable practices in the field of electric vehicle technology. Some partner universities are: Scuola Superiore Sant'Anna - Italy, and ETH Zurich - Switzerland.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Prof. Francesco Braghin, eng. Marta Gandolla

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	750.0 €
By number of months	6

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 6.114,50. 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. 750 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 630 Research Field: DEVELOPMENT OF AUTONOMOUS SENSORS AND ALGORITHMS BASED ON ARTIFICIAL INTELLIGENCE TECHNIQUES FOR THE CONDITION-BASED MAINTENANCE OF RAILWAY WHEELSETS

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	Infrastructures for sustainable mobility. Development of innovative solutions to support condition-based maintenance (CBM) and predictive maintenance of railway wheelsets, with the aim of increasing the level of reliability and safety and reducing operating costs.
Methods and techniques that will be developed and used to carry out the research	Current smart sensor technology will be applied and extended as part of the project. These solutions, achieved through previous research projects with PoliMi, have reached a maturity level of TRL4 (Technology validated in the laboratory). Within the scope of the proposed Ph.D. programs, with the opportunity to extensively test innovative solutions on operating railway vehicles, the development aims to advance to TRL8 (Complete and qualified system) by identifying the following research topics: In particular, the student will: •optimize intelligent sensor solutions (i.e., accelerometers, strain gauges, GPS) (equipped with microprocessors for real-time data processing, memory, and GSM connectivity) as a complement and addition to the two solutions currently already developed; •optimize the electric power management of the intelligent sensor based on different autonomous power supply solutions (i.e., vibration harvester, solar, battery) and integration with the sensors themselves, optimizing

	functionality and consumption; •develop of predictive models using artificial intelligence and machine learning techniques, capable of detecting in an advance defects and their evolution in service in order to better schedule maintenance stops of the vehicles; the typical defects will be: wheel rolling surface wear and rolling contact fatigue damages, bearing fatigue damages, wheelset axle fatigue cracks. •Development of data management solutions based on data analytics techniques; in particular, the development will focus on correlating the generated data with operating conditions to be able to predict the evolution of defects, correlated to the signals themselves, over time; •Development of data communication techniques between sensors and cloud servers, aiming to optimize the transmission of acquired data packets and verify their integrity and consistency on the server side.
Educational objectives	The student will learn: - research project management and publishing skills; - analytical models and experimental tests development skills (particularly identification algorithms, autonomous power supply solutions); - presentation and teaching skills.
Job opportunities	Employment statistics of POLIMI PhDs can be found at: https://cm.careerservice.polimi.it/en/employment-statistics/ Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. Companies in the transportation sector (Lucchini but also Bombardier, Alstom, Mercitalia Intermodal, Trenitalia,) will be very interested in hiring a PhD-graduate with application experience in the sector.
Composition of the research group	1 Full Professors 3 Associated Professors

	3 Associated Professors 3 Assistant Professors 4 PhD Students
Name of the research directors	Proff. Francesco Castelli Dezza, Gisella Tomasini

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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)	Lucchini RS S.p.A
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Chalmers University, Department of Mechanics and Maritime Sciences, Göteborg, Sweden
By number of months abroad	6

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 6.114,50. 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.

POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

PNRR 630 Research Field: DYNAMIC DATA-DRIVEN MODELLING FOR RAILWAY BRIDGE STRUCTURAL HEALTH MONITORING

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	Bridges serve as crucial arteries of connectivity, facilitating the flow of people and goods across regions. However, the relentless forces of weather phenomena and the escalating demands of ever-growing traffic have subjected these fundamental structures to accelerated wear and tear, surpassing the conservative estimates made during their initial design. Structural Health Monitoring (SHM) has emerged as a potent solution, harnessing the power of automated modelling techniques. The imperative to transition towards a data-driven approach has been driven by the escalating number of structures, necessitating algorithms that can generalize across diverse types of structures and sensors. The goal of SHM is to forecast a specific measured parameter of the bridge, facilitating the determination of its health status. SHM is, therefore, a key enabling factor for the infrastructure digitalization and increase of transportation safeness and availability, therefore complying with four of the six pillars mentioned in the Regulation (EU) 2021/241, which are: digital transformation, intelligent growth, territorial cohesion and economic resilience.
Methods and techniques that will be developed and used to carry out the research	The practical implementation of SHM methods for bridges passes through 4 main stages. i) measurement and acquisition system definition and installation ii) data acquisition and data storage iii) system modelling and

	iii) system modelling and iv) anomaly detection. The research will focus on stages iii and iv, that is, the system modelling and anomaly detection. In recent years it has been highlighted how data-driven dynamic modelling techniques are particularly suitable for SHM purposes. These approaches look for relations among the measured quantities by observing the data acquired from the bridge. Among the others, ARX, DMDC and SINDyC look particularly promising in the definition and construction of robust models. The second phase will involve instead the leveraging of these data-driven models to identify the onset of anomalies and possible damages from the structures. The candidate is expected to compare the above-mentioned techniques with state-of-the-art solutions for SHM, to justify the adoption of these innovative algorithms in comparison to more traditional approaches, such as the ones based on physical models suitable for structures (i.e. Mechanics of continuous bodies and Finite Elements Methods). The candidate must therefore be familiar with the handling and manipulation of real measurements coming from civil structures, as well as showcasing a strong background in traditional modelling techniques. These two core competencies will merge in an experimental test case, where the candidate will work mainly on a railway bridge on which a monitoring system will be installed according to a project already in place within a MOST partnership, involving a collaboration between the Mechanical Engineering Department and the sponsor company.
Educational objectives	The candidate is expected to develop strong basics in machine and deep learning, data-driven dynamics, numerical methods for engineering, structural health monitoring theory, anomaly detection and statistics.
Job opportunities	At the end of the experience, the candidate will be suitable for job opportunities in infrastructure manager companies, deep-tech startups, software houses leveraging AI solutions, National and International Research Institutes and worldwide renowned engineering Universities.

Composition of the research group	1 Full Professors 1 Associated Professors 1 Assistant Professors 4 PhD Students
Name of the research directors	Eng. Claudio Somaschini

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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)	Displaid S.R.L.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	MIT Senseable City Lab
By number of months abroad	6

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 or participation in courses, summer schools, workshops and conferences) for a total amount of euro 6.114, 50. 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.