POLITECNICO DI MILANO

# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

## THEMATIC Research Field: EXPERIMENTAL AND COMPUTATIONAL AEROACOUSTICS FOR ENGINEERING APPLICATIONS

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **€ 1500.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | Aerodynamic noise is a topic of growing importance in many application fields. This phenomenon is related to the turbulent structures capable of generating pressure waves synchronized on specific frequencies. The problem plays a fundamental role for example in the automotive industry, where electrification reduces noise emissions from other sources, such as the engine, and in the railway industry. In this context, the control of aeroacoustic sources is of great importance to mitigate noise both inside and outside the vehicle. The fact that sound is generated within the same medium through which it propagates increases the level of theoretical-experimental complexity and requires the development of dedicated modeling strategies and validation tools. In this sense, the research group has developed in recent years a numerical tool for computational aeroacoustics (AeroSPEED), based on a hybrid approach in which the solution of the acoustic problem with high-order numerical schemes allows an accurate and efficient solution of the sound field. However, an experimental validation of these methodologies through specific tests in controlled conditions, which also involves other research structures in Italy and around the world, is still an open point. Furthermore, in parallel with the validation phase, a possible improvement of the methodology, considering and comparing alternative acoustic models and the possibility of integrating tools for reducing computational and storage requests (POD, Proper Orthogonal |

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| | Decomposition, and DMD, Dynamic Mode Decomposition) is of great interest. Finally, the calculation tool can be applied to some real case studies.The research project therefore aims at improving the knowledge of aeroacoustic phenomena and at developing possible solutions for mitigating aerodynamic noise. This will support the technological development of industrial sectors that face the problem of designing increasingly silent products, with indisputable benefits for people's health and well-being. |
| **Methods and techniques that will be developed and used to carry out the research** | This research is characterized by a strong interdisciplinary approach. The skills of the DMAT MOX laboratory will allow to refine advanced numerical schemes to solve aero-acoustics problems. These skills will be integrated with DMEC theoretical and experimental knowledge in the fluid dynamics and acoustic fields. The CFDHub interdepartmental laboratory will provide the computing capabilities to solve the numerical problems. At the same time, an experimental setup will be developed for the validation of the model in a aeroacoustic wind tunnel. The PSVL interdepartmental laboratory will provide the instrumentation for the experimental tests. During the first phase, the research activity will focus on the validation of the methodology by analysing simple case studies, for which a benchmarking activity with other research institutes can be carried out. In the second phase, the model will be applied to case studies of industrial relevance, with particular reference to the automotive and railway sectors. |
| **Educational objectives** | The candidate will acquire high-profile skills and will be working on one of the most significant and challenging problems in NVH engineering, dealing with both theoretical and experimental methodologies. He/she will become an expert in aeroacoustic modelling and experimental testing, including signal processing and system identification. The candidate is supposed to provide original contributions to the development and experimental validation of innovative simulation tools. |
| **Job opportunities** | Future job opportunities are primarily in the automotive |

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| | field (especially in NVH area), i.e. R&D departments of automotive industries (including automobile manufacturers and vehicle component suppliers in general). Besides this, job opportunities comprise national and international academic and nonacademic institutions and organizations, engaged in innovation, research and technical development.<br>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. |
| **Composition of the research group** | 1 Full Professors<br>3 Associated Professors<br>1 Assistant Professors<br>2 PhD Students |
| **Name of the research directors** | Proff. Roberto Corradi, Ilario Mazzieri (DMAT) |

| **Contacts** |
|---|
| 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 € 6.114,50.<br>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).<br>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

## THEMATIC Research Field: DESIGN OF SPECIAL COMPONENTS IN ROTATING MACHINES FOR ENERGY TRANSITION

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **€ 1500.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | The development of rotating machines for the energy transition requires a new approach to design, aimed at a priori verification of stability, given the lack of existing references and the fact that - probably in the medium term - all machines will be one of a kind. In particular, the use of working fluids, now generally considered as unconventional, such as hydrogen, carbon dioxide, organic fluids, requires the use of particularly effective seals, also for performance purposes, and, sometimes, of bearings that use the same working fluid. Regarding seals, those of the "honeycomb" type will generally be preferred to labyrinth ones, sometimes coupled with brush-seals. This together determines the need to calculate the dynamic coefficients in a cost-effective manner in the face of CFD models with a huge number of nodes and to effectively resolve the non-linear problems that are determined by the contact of the brushes which can induce an instability called "a spiral". The use of working fluids as lubricants simplifies the design from the point of view of containment and contamination, but raises the problem of modeling the fluid in multiphase conditions, in special models in the case of sCO2. |
| **Methods and techniques that will be developed and used to carry out the research** | Alongside conventional CFD models, implemented with commercial software, methods will be used that allow the extrapolation of results in the face of variations in operating parameters on the basis of a limited set of AI-based simulations |

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| | based simulations |
| **Educational objectives** | The candidate will develop a solid knowledge in modeling some critical components of modern rotating machines designed for the energy transition. |
| **Job opportunities** | List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in the research include: Baker Hughes – Nuovo Pignone, Ansaldo Energia, Exergy, Turboden, Texas A&M University (USA), Université de Poitiers (FR), Northwestern Polytechnical University (PRC), Tsinghua University (PRC) |
| **Composition of the research group** | 1 Full Professors<br>2 Associated Professors<br>0 Assistant Professors<br>5 PhD Students |
| **Name of the research directors** | Prof. Paolo Pennacchi |

| **Contacts** |
|---|
| 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** |
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| 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.<br>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).<br>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**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **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.<br><br>The research activity is financed and developed within the Sustainable Mobility Center (Centro Nazionale per la |

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| | 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.<br>Norms of reference: CUP D43C22001180001 - D.D. 1033 del 17/06/2022;<br>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.<br>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. |

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| **Composition of the research group** | 1 Full Professors<br>0 Associated Professors<br>0 Assistant Professors<br>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.<br>*E-mail*: francesco.braghin@polimi.it<br>For questions about scholarship/support, please contact phd-dmec@polimi.it |

| **Additional support - Financial aid per PhD student per year (gross amount)** | |
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| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents (more than 80Km out of Milano)** | -- |

| **Scholarship Increase for a period abroad** | |
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| **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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| 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.<br>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).<br>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**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **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. |

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| | 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.<br>Norms of reference: CUP D43C22001180001 - D.D. 1033 del 17/06/2022;<br>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:<br>•develop a proficiency in statistical analysis tools and methodologies, particularly causal inference;<br>•gain hands-on experience in developing simulation tools and establishing digital twins of vehicle-control- |

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| | environment systems;<br>•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.<br>Some partner universities are: Scuola Superiore Sant'Anna - Italy, and ETH Zurich - Switzerland. |
| **Composition of the research group** | 1 Full Professors<br>0 Associated Professors<br>1 Assistant Professors<br>2 PhD Students |
| **Name of the research directors** | Prof. Francesco Braghin |

| **Contacts** |
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| *Phone*: 02 2399 8306 *Email*: francesco.braghin@polimi.it, marta.gandolla@polimi.it<br>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.<br>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).
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POLITECNICO DI MILANO

# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

## THEMATIC Research Field: AUTONOMOUS ROBOTIC SOLUTION FOR EV BATTERY DISASSEMBLY

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **€ 1500.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | In light of pressing societal issues, such as climate neutrality, industry digitization, and the circular economy, this PhD focuses on enhancing recycling practices for electric vehicle (EV) battery packs. The specific goal is to develop and apply advanced robotics solutions utilizing reinforcement learning (RL) techniques for the autonomous disassembly of EV battery packs. By integrating robotics and machine learning, it will be possible to address the associated critical issues, such as<br>- safety (i.e., ensuring the safety of both the operators and the environment during the disassembly process)<br>- efficiency (i.e., maximizing the speed and effectiveness of the disassembly process)<br>- complexity (i.e., EV battery packs are composed of multiple components that are tightly integrated, making the disassembly process intricate and challenging)<br>- sustainability (i.e. promoting sustainable practices during the disassembly process) |
| **Methods and techniques that will be developed and used to carry out the research** | The candidate will start the research by delving into robotics and machine learning algorithms. On the one side, currently developed robotic systems for disassembly (especially targeting the automotive sector) will be analyzed. 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's already available in the considered domain before designing ad hoc methodologies. Drawing |

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| | domain before designing ad hoc methodologies. Drawing upon existing studies and software (e.g., robotic simulation environments such as Isaac Gym), the candidate will devise strategies and codes to tackle the aforementioned challenges effectively. Then, the candidate will develop learning (e.g., RL and generative AI) and sim2real - real2sim algorithms to address the target disassembly task. Finally, experimental tests will be performed to evaluate the performance of the robotic system in the proposed context. This work is within the AUTOMAT project, a Horizon EU-funded project with international partners (both academic and industrial partners). |
| **Educational objectives** | The PhD candidate is expected to develop solid competencies in robotics and machine learning (especially considering RL and generative AI). 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** | 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. Some partner universities are: Technical University of Munich (TUM) - Germany, University of Oxford - UK, and ETH Zurich - Switzerland. |
| **Composition of the research group** | 1 Full Professors<br>0 Associated Professors<br>1 Assistant Professors<br>2 PhD Students |
| **Name of the research directors** | Prof. Francesco Braghin |

| **Contacts** |
|---|
| *Phone*: 02 2399 8306 *Email*: francesco.braghin@polimi.it<br>For questions about scholarship/support, please contact phd-dmec@polimi.it |

| **Additional support - Financial aid per PhD student per year (gross amount)** |
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| **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: LEARNING-BASED MODEL PREDICTIVE IMPEDANCE/ADMITTANCE CONTROL FOR THE EXECUTION OF CHALLENGING MANIPULATION TASKS

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **€ 1500.0**<br>In case of a change of the welfare rates during the three-year period, the amount could be modified. |

| Context of the research activity | |
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| **Motivation and objectives of the research in this field** | The research is motivated by the pressing need for advanced control strategies in robotics to enable the execution of complex manipulation tasks in dynamic and uncertain environments. Traditional control methods often struggle to handle challenging scenarios involving contact interactions and variable object properties. By integrating model predictive control (MPC) with impedance/admittance control techniques, this research aims to develop a novel learning-based control framework. Leveraging machine learning algorithms such as reinforcement learning or deep learning, the goal is to enable robots to learn the dynamics of manipulation tasks and adapt control parameters in real-time.Through simulations and experiments on robotic platforms, the effectiveness of the proposed control approach will be validated, assessing its performance in executing challenging manipulation tasks under varying environmental conditions and object properties. Potential applications are in industries requiring high-precision manipulation, such as assembly, pick-and-place operations, and object manipulation in cluttered environments. |
| **Methods and techniques that will be developed and used to carry out the research** | The PhD student will develop and apply several methods and techniques which include:<br>•MPC algorithms to predict and optimize the robot's future |

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| | states and control actions;<br>•design and implement impedance and admittance control strategies to regulate the interaction forces between the robot and its environment;<br>•RL algorithms to enable the robot to learn optimal control policies through trial and error;<br>•DL techniques to process and interpret complex sensory data, such as visual inputs from cameras or force measurements from sensors;<br>•simulation environments and digital twins of the robotic system to test and validate control algorithms;<br>•experiments to validate the developed control strategies on physical robotic platforms. |
| **Educational objectives** | The educational objectives are to equip students with an in-depth understanding of advanced control methodologies, enhance their problem-solving skills in complex engineering scenarios, and provide hands-on experience in designing and testing control strategies on robotic platforms. Additionally, the research aims to foster interdisciplinary integration, encouraging the synthesis of concepts from mechanical engineering, computer science, and artificial intelligence. |
| **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. The research is carried out in collaboration with Leonardo LABS. |
| **Composition of the research group** | 1 Full Professors<br>0 Associated Professors<br>1 Assistant Professors<br>2 PhD Students |
| **Name of the research directors** | Prof. Francesco Braghin |

| Contacts |
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| *Phone*: 02 2399 8306 *Email*: francesco.braghin@polimi.it, marta.gandolla@polimi.it<br>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 |

| National Operational Program for Research and Innovation | |
|---|---|
| **Company where the candidate will attend the stage (name and brief description)** | Leonardo 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)** | to be defined |
| **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 euro 6.114,50.<br>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

## THEMATIC Research Field: RESPONSE OF STRUCTURE DYNAMICS TO TURBULENT FLOWS

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **€ 1500.0**<br>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 study of the atmospheric boundary layer and its interaction with civil and mechanical structures is of fundamental importance to understand the impact of flow turbulence not only on static structures, but also on dynamic structures. The activity is meant to be conducted using Computational Fluid Dynamics (CFD) using an open-source framework. The first objective of the study is to reproduce the relevant characteristics of the atmospheric wind both considering the average flow, as well as the unsteady features. The impact of the turbulent wind will be evaluated on dynamic structures, such as wind turbines in the wind energy field and suspension bridges and high rise buildings in the wind engineering field. Wind turbines are generally clustered in arrays as wind farms, the interaction between them happens through the wake interaction that is strongly affected by the wake mixing induced by the wind turbulence. Suspension bridges are subject to wind forces associated to their relative wind incidence angle. The relative wind can be imputed to vertical displacement of the bridge section, or to rotation of the bridge section: these motions can be calculated considering the dynamics of the entire bridge. A complimentary approach that uses the bridge aerodynamic coefficients and the flutter derivatives for bridge sections, that can be calculated using CFD in smooth and turbulent flow. High rise building are impacted by turbulent flow, that affect the loads on the structure as well as on the cladding. Wind turbulence affects the |

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| | dynamics of the building, inducing oscillatory motion. |
| **Methods and techniques that will be developed and used to carry out the research** | The work will be done coupling Computational Fluid Dynamics (CFD) models with system dynamics models. The CFD framework will be open-source and a HPC infrastructure will be used. Experimental activity will be performed to gather data suitable for the validation of the numerical models and the response of the structures. Post-processing of CFD results will allow to gather more insight in the physical phenomenon, giving some additional information for understanding the interaction of structures with turbulent flow. |
| **Educational objectives** | Develop advanced CFD models that combine Fluid-Dynamics and System Dynamics.<br>Experimental background to have a physical understanding of the phenomenon.<br>Combine and master different modelling techniques.<br>Develop competences on innovative components.<br>Multi-disciplinary competencies.<br>Methodological competences at both the theoretical and applied level.<br>Problem setting and solving capabilities.<br>Develop team-working attitude. |
| **Job opportunities** | Wind Energy and Wind Engineering field<br>CFD specialist<br>Vehicle aerodynamics<br>Bridge aerodynamics |
| **Composition of the research group** | 3 Full Professors<br>3 Associated Professors<br>2 Assistant Professors<br>5 PhD Students |
| **Name of the research directors** | Proff. Paolo Schito, Alberto Zasso |

| **Contacts** |
|---|
| 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.