ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

MUR DM 117/CIM 4.0 - Research, development, and prototyping of novel AI-based solutions for industrial robotics and mechatronics

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Competence Industry Manufacturing 4.0 S.C. A R.L. [P.iva/CF:12039730010] Politecnico di TORINO [P.iva/CF:00518460019]
Supervisor	RIZZO ALESSANDRO - alessandro.rizzo@polito.it
Contact	RIZZO ALESSANDRO - alessandro.rizzo@polito.it
Context of the research activity	This PhD fellowship focuses on exploring, developing, and prototyping novel AI-based solutions for mechatronics and industrial robotics. The research aims to harmonize state-of-the-art AI technologies, such as machine learning and deep learning, and traditional control techniques, to optimize control of robotic systems, manufacturing processes, enable autonomous systems and robots, and foster human-robot collaboration. Progetto finanziato nell'ambito del PNRR – DM 117/2023 - CUP E14D23002000004
	Introduction: This research plan aims to develop groundbreaking AI-based solutions for mechatronics and industrial robotics by integrating traditional modeling and control techniques with AI technologies. The research will leverage physics informed neural networks to predict and control complex and nonlinear phenomena. The collaboration with CIM 4.0, a leading company in the field, will facilitate real-world validation and application of the developed solutions. This research plan aims to revolutionize mechatronics and industrial robotics by integrating AI-based solutions with traditional modeling and control techniques. Collaboration with CIM 4.0 will ensure real-world applicability, paving the way for enhanced automation, improved efficiency, and intelligent decision-making in manufacturing and automation industries. In the following, the main objectives and steps of the research will be highlighted. Literature Review:

Objectives	Conduct an extensive literature review to comprehend the existing state-of-the-art in AI, mechatronics, and industrial robotics. Investigate traditional modeling and control techniques used in these fields and explore recent advances in physics informed neural networks to bridge the gap between the known and unpredictable phenomena. Objective 1: Integration of Traditional Techniques Develop a comprehensive framework to model known mechatronic and robotic systems using traditional techniques. Utilize system identification, control theory, and mathematical modeling to represent stable and predictable behaviors. This framework will serve as the baseline for comparison with AI-based solutions, highlighting the added value of AI in addressing the complexities of unpredictable and nonlinear dynamics. Objective 2: AI-Based Solutions Explore advanced AI algorithms such as deep learning, reinforcement learning, and physics informed neural networks to predict and control highly unpredictable and nonlinear phenomena in mechatronics and industrial robotics. Design and train neural networks capable of learning from data and incorporating physical principles into their structure to improve accuracy and reliability. Objective 3: Hybrid AI-Traditional Control Develop a hybrid AI-Traditional control approach that seamlessly integrates the strengths of both methodologies. Implement AI-based controllers for unpredictable dynamics while utilizing traditional control strategies for stable regions. Investigate methods to achieve smooth transitions between AI and traditional control modules to ensure safe and efficient operation. Objective 4: Prototyping and Testing Prototype and validate the developed AI-based solutions in real-world manufacturing and automation environments, in collaboration with CIM 4.0. Conduct comprehensive testing to evaluate the performance, reliability, and scalability of the AI-integrated mechatronic and robotic systems. Compare the results against traditional techniques to quantify the improvements brought by AI. Objective 5: Human-Robot Collaboration Explore the application of AI-based solutions to foster human-robot collaboration in shared workspaces. Develop algorithms that enhance robot adaptability and responsiveness to human actions while ensuring safety and efficiency. This research will lay the foundation for advanced human-robot interactions in industrial settings, improving productivity and worker well-being. Objective 6: Industry Impact Assess the potential impact of the developed AI-based solutions on the mechatronics and industrial robotics industries. Analyze the cost savings, productivity gains, and environmental benefits achieved through increased automation and efficient resource utilization. Provide CIM 4.0 with recommendations for implementation strategies to drive industry-wide advancements.

Skills and competencies for the development of the activity	- Strong background in mechatronics, robotics, or related engineering fields - Experience in modeling and control techniques for robotics and/or mechatronic systems - Previous experience in industrial robotics or automation is desirable. - Programming skills in Python, MATLAB, or other relevant languages - Knowledge of a specific robotic-oriented simulation framework (e.g., ROS) constitutes a strong plus - Ability to conduct research, design experiments, and analyze data