POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

THEMATIC Research Field: INNOVATIVE METHODOLOGICAL APPROACHES IN BIOMECHANICAL MODELLING AND WEARABLE TECHNOLOGIES FOR 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	Wearable technologies have evolved rapidly into multidisciplinary tools with applications in health monitoring, sports performance optimization, and personalized well-being interventions. Recent methodological innovations in wearable technologies have driven significant transformations across various domains. Cutting-edge approaches now combine advanced sensor systems with Artificial Intelligence (AI) models to provide real-time personalized health monitoring, rehabilitation program optimization, stress management, and injury prevention within occupational settings. These innovations empower rehabilitation processes by offering dynamic, real-time feedback that helps tailor therapeutic interventions and accelerate recovery. Furthermore, advanced prosthetics are increasingly incorporating wearable sensor arrays and haptic feedback mechanisms, often embedded in e-textiles, to deliver more natural control and better adaptation to individual users' needs. Wearable systems are also increasingly being integrated into sports with digital coaching platforms, enabling tailored training regimens and proactive performance management. The integration of biomechanical modeling has further paved the way for robust and explainable data analytics, bridging the gap between raw sensor data and actionable health insights. These methodological advances foster a shift towards proactive, data-driven, and personalized approaches in healthcare and well-being, as well as sports. However, when focusing on

	sports, particular attention must be given to integration and interoperability, user comfort, and overall adoption, as well as cost and accessibility. The proposed research aims to address the current technological limitations, interdisciplinary integration challenges, and real-world implementation gaps in the defined domains. In particular, the research seeks to target the specific challenges within each domain, including: •Define specific sports scenarios and identify use cases where wearable technologies can play an enabling role. •Conduct an up-to-date analysis of wearable technologies and biomechanical modellig present in the current scientific literature and on the market for those specific scenarios. •Develop and implement new methodological approaches for implementing wearables with e-textile, and biomechanical modeling •Iterate through the design-based research process to implement and verify the proposed approaches •Validate the developed approaches within the defined scenarios.
Methods and techniques that will be developed and used to carry out the research	An inherently multidisciplinary approach will be adopted during the development of research activities. This approach combines wearable technologies, e-textile, biomechanical modeling, and a deep understanding of the application domains, all integrated with design methods to ensure the effectiveness of the proposed solutions. Key techniques include: •Defining appropriate scenarios of interest with diverse use cases and users. •Conducting a systematic review of current solutions and analyzing the market-identified approaches for each identified scenario •Adopting specific design frameworks, such as Design-Based Research (DBR), to bridge engineering and user

	experience within specific use cases. This facilitates effective development and refinement processes through advanced prototyping technologies. •Integrating advanced biomechanical modeling techniques to support the development of predictive approaches for monitoring, injury prevention, performance optimization, and personalized intervention during rehabilitation. •Evaluating ethical issues and assessing translational impact. This methodological framework aligns with emerging needs in evidence-based sports science, providing a roadmap for advancing the current state-of-the-art of wearables.
Educational objectives	The proposed research aims to address both technical-scientific and soft skills and expertise. Specifically, the technical-scientific objectives include: •Gaining in-depth knowledge of wearable systems, e-textiles, and biomechanical modeling. •Developing interdisciplinary literacy and familiarity with the principles of sports science, including paralympic sports, to bridge engineering innovations with domain-specific needs. •Learning how to conduct comprehensive reviews of academic literature and market solutions to identify gaps and current trends in wearable technology and biomechanical modeling. •Developing skills to define, model, and analyze specific scenarios and user cases where wearable technologies can be most effectively applied. •Mastering design-based research (DBR) methodologies to iteratively design, develop, and refine prototypes in real-world contexts, ensuring the development of comfortable and accessible solutions that can be seamlessly integrated into users' lives, thus promoting higher adoption rates. •Engaging in hands-on development and testing of wearable systems, integrating digital solutions and e-

	textiles with biomechanical models for continuous feedback. •Acquiring expertise in processing and analyzing complex sensor data, enabling real-time monitoring and feedback. •Developing and validating predictive models to optimize rehabilitation, performance management, injury prevention, etc. •Developing and validating biomechanical models that can support the identification of specific metrics to predict specific behaviors •Learning the ethical and legal frameworks surrounding data integrity, privacy, and security, ensuring that wearable solutions comply with regulatory standards. •Learning methods for iterative testing and real-world validation of prototypes within defined scenarios, including the use of pilot studies within clinical contexts, so as to assess the broader impact of technological innovations, translating laboratory findings into practical, scalable solutions in healthcare and sports. The educational objectives concerning soft skills include: •Developing competencies in managing collaborative projects that involve engineers, clinicians, sports scientists, and designers •Enhancing skills in effectively communicating complex technical and research findings to both academic and non-technical audiences, ensuring proper knowledge transfer. These objectives are designed to ensure that the PhD candidate not only develops deep technical expertise but also gains a comprehensive understanding of the socio-ethical, methodological, and translational aspects required for advancing wearable technologies in evidence-based sports science.
Job opportunities	Given the inherently multidisciplinary nature of the proposed research, the PhD student will have the opportunity to collaborate closely with professionals from diverse fields, such as engineering, healthcare, sports

	science, human-computer interaction, and design. This collaborative environment will serve as a foundation for developing the ability to work effectively within interdisciplinary teams, an essential skill in both academic and industry research settings. Throughout the PhD journey, the candidate will progressively build strong competencies in managing complex research workflows, from the ideation and prototyping phases to iterative testing and real-world validation. This will foster a high degree of autonomy, enabling the student to take ownership of the creative and methodological processes that support innovative technological solutions. By the conclusion of the PhD, the student will be equipped with a comprehensive skill set that supports career opportunities both within academia and in industry. Specifically, they will be well-prepared for roles in research and development departments of companies working on wearable technologies, smart textile and biomechanical modeling—sectors that are rapidly expanding in today's job market. Additionally, the mandatory international research internship will provide valuable exposure to global research environments, significantly broadening the student's professional network and enhancing their employability. The student will also actively participate in national and European research projects, often involving large consortia of universities, research centers, and companies. These collaborative initiatives will further strengthen their experience in project management, multidisciplinary teamwork, and translational research, while also opening doors to long-term career opportunities in innovation-driven sectors.
Composition of the research group	2 Full Professors 1 Associated Professors 2 Assistant Professors 3 PhD Students
Name of the research directors	Proff. M. Tarabini, N. Lopomo, G. Andreoni

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

Scholarship Increase for a period abroad	
Amount monthly	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 € 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). Additionally, PhD candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3,000 to cover travel expenses. 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.