POLITECNICO DI MILANO

PhD in BIOINGEGNERIA / BIOENGINEERING - 41st cycle

THEMATIC Research Field: SMART FOOTWEAR AND ARTIFICIAL INTELLIGENCE APPLIED TO BIOMECHANICAL GAIT ANALYSIS, WITH A FOCUS ON INJURY PREVENTION AND PERFORMANCE OPTIMIZATION

Monthly net income of PhDscholarship (max 36 months)
1400.0 In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity	
Motivation and objectives of the research in this field	The PhD Scholarship is focused on the development and application of smart wearable technologies, specifically intelligent footwear, integrated with artificial intelligence tools to analyze human gait in real-world conditions. This project lies at the intersection of biomechanics, sensor technology, and data science, with the overarching goal of improving both injury prevention strategies and performance optimization in clinical, occupational, and sports settings.The project responds to the growing demand for ecologically valid and non-invasive gait analysis tools, which can be used outside of laboratory settings. In particular, smart footwear equipped with pressure sensors, inertial measurement units (IMUs), and wireless communication capabilities allow for continuous and detailed tracking of lower limb biomechanics during daily activities or athletic performance.The PhD project will aim to develop novel AI-based models capable of processing large-scale movement data collected from wearable devices to: •detect abnormal gait patterns that may indicate early signs of musculoskeletal or neurological impairments; •monitor functional improvements over time, especially in rehabilitation and return-to-activity pathways; •predict the risk of injury based on biomechanical markers and loading patterns; •provide real-time feedback to optimize gait performance

	in athletes or individuals with specific mobility needs. The specific aims of the PhD Project are: •development of AI algorithms for gait pattern recognition, anomaly detection, and predictive modeling; •comparison of traditional lab-based gait analysis methods with wearable-based data acquisition in outdoor or semi-structured environments; •application of the system to case studies in injury prevention, sports performance, and clinical rehabilitation. This interdisciplinary research will contribute to the advancement of personalized movement analytics and support the transition toward preventive and precision approaches in human movement science.
Methods and techniques that will be developed and used to carry out the research	The PhD project will be developed in collaboration with the company LUBU Technologies, Inc. and will be carried out at Polimi Movement Analysis Labs (Human Performance Lab in Lecco and “L.Divieti” Lab at DEIB) and at LUBU company.The following methods and techniques will be developed and applied: •**Biomechanical Signal Processing**: Pre-processing pipelines will be implemented to clean, segment, and synchronize multi-sensor data. This includes filtering, event detection (e.g., heel-strike and toe-off), and feature extraction (e.g., step length, cadence, center of pressure trajectory). •**Motion Capture Integration**: Where applicable, data from smart footwear will be validated or complemented with other motion analysis systems, allowing for a comprehensive 3D reconstruction of gait patterns in both laboratory and non-laboratory settings. •**Artificial Intelligence and Machine Learning**: Supervised and unsupervised learning models (e.g., convolutional neural networks, recurrent neural networks, clustering algorithms) will be trained to automatically classify gait patterns, detect anomalies, and predict injury risk or recovery trends. •**Longitudinal Data Collection and Analysis**: Data will

	be collected over time to track changes in gait related to rehabilitation, fatigue, or training. Time-series analysis and personalized baselines will be used to assess performance variation and recovery trajectories. •**Experimental Validation and Use Cases**: The developed system will be validated through pilot studies with healthy individuals and selected populations at risk (e.g., athletes, workers in physically demanding roles, patients in rehabilitation). Comparisons will be made with gold-standard gait lab instrumentation to assess accuracy and usability. This integrated methodological framework will support the development of **robust, field-deployable tools** for gait analysis with high translational potential in injury prevention and performance optimization.
Educational objectives	The candidate will be trained in the methodologies to best develop not only the project but also her/his skills to become a leading researcher. In the end the candidate will have the skills and abilities to operate as a researcher and innovator mastering the problems to be addressed with qualitative and quantitative approaches.
Job opportunities	The PhD student will have the opportunity to create a background and skills useful for further job applications.
Composition of the research group	1 Full Professors 1 Associated Professors 3 Assistant Professors 4 PhD Students
Name of the research directors	Prof. Manuela Galli - Dr. Luca Buratto

Contacts
Prof. Manuela Galli *Manuela.galli@polimi.it* *Dr Luca Buratto (LUBU)* *Luca@lubu.ai*

Additional support - Financial aid per PhD student per year (gross amount)

Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

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

Educational activity: The student will be encouraged to attend to courses at POLIMI or abroad 2 / 3in International Schools. Teaching assistantship: 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. Computer and desk availability: the student will be allowed to access facilities of the DEIB.