Final Defense

PhD Course in Bioengineering – Final Thesis Defense

PhD Candidate: MATTEO SPOSITO
Advisor: Prof. Elena De Momi
Prof. Jesus Ortiz

07.07.2021
h. 10:00
@ Microsoft Teams

Thesis: ERGONOMICS OF OCCUPATIONAL EXOSKELETONS: EVOLVING DESIGN AND ASSESSMENT METHODOLOGIES OF PHYSICAL ATTACHMENTS

COMMITTEE MEMBERS

Prof. Leonard O'Sullivan	Prof. Tom Verstraten	Prof. Simona Ferrante
University of Limerick School of Design Faculty of Science and Engineering Ireland	Vrije Universiteit Brussel (VUB) Department of Mechanical Engineering, Faculty of Applied Science	Politecnico di Milano, MILANO

SCHEDULE OF THE DAY

10:00 – 10:15	Committee Meeting
10:15 – 11:15	Thesis presentation – Discussion
11:15 – 11:30	Committee meeting
11:30	Award Ceremony

Politecnico di Milano
Dipartimento Elettronica Informazione e Bioingegneria
Dipartimento Chimica, Materiali, Ingegneria Chimica «Giulio Natta»
Via Ponzio 34/5 - 20133 Milano

PhD Chairman
Prof. Andrea Aliverti
andrea.aliverti@polimi.it

PhD Secretariat
Phd-BIO@polimi.it
phone +39 02 2399 3632

PhD in Bioengineering

Final Defense

POLITECNICO MILANO 1863

PhD student: **MATTEO SPOSITO – XXXIII Cycle**

Thesis title: ERGONOMICS OF OCCUPATIONAL EXOSKELETONS: EVOLVING DESIGN AND ASSESSMENT METHODOLOGIES OF PHYSICAL ATTACHMENTS

Advisor: Prof. Elena De Momi – Deib - Politecnico di Milano
Prof. Jesus Ortiz – Fondazione IIT Genova

Abstract:

WORK related Muskoskeletal disorders (WMSDs) undermine safety and wellness of workers and companies productivity. Annually, there is a growing impact of WMSDs due to the ageing working class, that is more likely to develop a WMSDs for working longer in physical wearing tasks (e.g. manual material handling, over-head assembly and un-ergonomic static postures). Ergonomics guidelines are a mitigation strategy to reduce the risk of injury and often results in limitations of weights or task frequencies. Industrial automation is a viable solution to address the problem and relieve the strain from the workers. However, unstructured workplaces, high costs, failsafe plans to ensure continuous availability of the services and social consequences do not encourage investing in high-level automation. Occupational wearable robots rise as a feasible alternative solution to address WMSDs. Wearable assistive robots, or exoskeletons, can be regarded as a parallel kinematic chain secured to the biological kinematic chain (limbs and articulations) of the users. The scope of an exoskeleton is to unload biological joints from physical overload (or stress) resulting from repetitive and un-ergonomic tasks. Nevertheless, adoption from the endusers (workers) is low. A key factor to improve acceptability is to improve ergonomics of the wearable assistive robots designed for industrial tasks (hereinafter referred to as occupational exoskeletons). Exoskeletons' ergonomic can be affected by these factors: (i) modalities of assistive force delivery, (ii) body segments where assistance is unloaded and (iii) hindrance to users' movements. All these three effects are mostly part of the physical attachments' domain. In this thesis, we refer as physical attachments to any cuffs, braces, garments or harnesses that secure exoskeletons to user's limbs. The state-of-the-art physical attachments relies on design from orthotic devices, protective or sport equipment. However, those designs fail to satisfy both freedom of movement and a secure fit on all movements. In fact, subjects often report slippage of the attachments, excessive pressure on limbs or sores. These negative effects can be ascribed to unpredicted constraint forces F and torques T at the attachments. The shear components of force F loosen the attachments and can create sores on the skin. While torque T and normal components of F negatively affects assistive force transmission, freedom of movement and the attachments' ergonomics. Therefore, occupational exoskeletons can I not deliver assistance forces efficiently while permitting complete freedom of movement to their users. To this end, the overall aim of this thesis is to investigate the influence of physical attachment's design on occupational exoskeletons physical ergonomics, as a matter of physical comfort, and force ransmission efficiency. As a pilot application, in this thesis is presented the ergonomic design of braces for XoTrunk, an occupational lower-back support exoskeleton. Such approach can have positive effects to promote acceptance and, consequently, dropping the incidence of WMSDs on an ageing working population. All the developed simulations and survey tools are tested on different prototypes of the attachments for a back-support exoskeleton in the scope of the sponsored project IIT-INAIL "Sistemi Cibernetici Collaborativi". Indeed, this project supports the further development of active occupational exoskeletons to address the problem of WMSDs at the lower-back and at the shoulders. In addition, this project supports pilot field application and collaboration with several stakeholders (i.e. RSPP, companies and employees) to promote exoskeletons as new tools for enhancing workers' safety and wellness.