Master's Department of Engineering Sciences

MSc in Automation Engineering and Robotics

Name of the unit: Wearable Robotics

Lecturer: Nathanaël Jarrassé Xavier Bonnet (jarrasse@isir.upmc.fr Xavier.BONNET@ensam.eu)
Course code: UM5RBM32
Student workload: 6 h of lectures, 16 h of labs
Credits: 3 ECTS
Specialization tracks: ☒ ROBOT (elective) ☐ SI ☒ MeDH
Semester offered: ☐ S1 ☐ S2 ☒ S3 ☐ S4
Language of instruction: ☐ French ☒ English
Targeted audience: ☒ Engineering Sciences students ☐ Other (specify): ENSAM
Localization : ☐ PMC Campus ☐ Other (specify):

Course Overview

Wearable robotics involves portable technological devices designed to assist movements and enhance human physical capabilities. These innovations present crucial challenges in terms of safety and integration while offering significant opportunities for medical rehabilitation, industrial productivity, and quality of life improvement. Wearable robotics face challenges in miniaturization, energy autonomy, material flexibility and user interfaces.
Keywords: Werable robotics

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Trigonometry
- Basic kinematics/dynamics of rigid bodies
- Basic knowledge of control systems (PID control)

Intended Learning Outcomes

By the end of this course, students will be able to:

1. Develop a comprehensive understanding of wearable robotics, including key concepts, current research, industry applications, and ethical considerations.
2. Utilize traditional sensors for intent detection and measure motor activity with embedded systems. (inertial, effort, myoelectric)
3. Implement and evaluate interaction control strategies (impedance, admittance, effort).
4. Establish evaluation protocols for device impact based on literature standards.
5. Select appropriate control strategies based on application needs and user capabilities.
6. Dimension actuators for force versus reversibility, considering reduction and transparency.
7. Design and implement devices with appropriate instrumentation and interfaces, compensating for negative effects like inertia and friction.

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1-C2 (2x3h)	Two coursesthat explores the application areas of wearable robotics, introduces the requirements for embedded systems interacting with the human body, covers the technological complexity from passive to active systems, and discusses both traditional sensor/actuators technologies and the latest advancements in the field. Special emphasis will be placed on prosthetics and exoskeletons for both upper and lower limbs.	ENSAM and SU	AAV1, AAV2, AAV6
S2	C1-C2	"		AAV1, AAV2, AAV6
S3	TP1 (4h)	Students will learn to measure human movement using embedded sensors, specifically focusing on IMU (Inertial Measurement Units). Practical exercises will involve real-time monitoring and data interpretation to apply these measurements in wearable robotics applications.	ENSAM	AAV2
S4	TP2 (4h)	Design and implement software concepts (dynamic systems modeling, open/closed loop control and PID controller). Students will learn about the main control loops used in wearable robotics systems, such as open-loop feedforward control for gravity compensation in quasi-static conditions.	SU	AAV2, AAV3, AAV4
S5				
S6	TP3 and TP4	This practical work, conducted over two sessions, focuses on gait control through the modeling of a State Machine. The objective is to implement a control algorithm capable of managing the different phases of the gait cycle (stance, swing, etc.) for a leg prosthesis, specifically targeting the ankle joint. Students will implement the entire control chain (including the state machine) onto the active Synsys prosthesis.	ENSAM	
S7				
S8	TP5	Electromyography (EMG) signals and pattern recognition (classification). Students acquire EMG signals (using devices like Myoband) and implement classification algorithms to interpret muscle activity patterns. The objective is to map these patterns to specific intentions or movements, which is crucial for commanding a prosthesis.	SU	AAV2, AAV5
S9	TP6	Control Implementation on an Exoskeleton ...	SU	AAV3, AAV7
S10				
S11				
S12				
S13				
S14				
S15				

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S3	Group	In-person	TP	AAV1, AAV2, AAV3	25 %
S6	Group	In-person	TP	AAV1, AAV2, AAV3, AAV5	50 %
S10	Individual	In-person	Quiz	AAV1, AAV2, AAV3, AAV5	25 %

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Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %

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