Course Title: Sensori-motor behavior, motor learning, and the haptic function

Course description	
Course components	38h CM; 8h TP; 14h Project
European credits	6 ECTS
Master specialization	Ingénierie pour la santé / Mechatronic Systems for Rehabilitation
Semester	S3

a) Objective

The goal of the course is to introduce the students to models and empirical findings regarding the sensorimotor behavior in humans and associated learning and its contributions to purposeful and discriminative touch. This course has two parts. In the first, the students are exposed to the current theories that underlie the computational approaches to the study of motor control and they are provided with a general background in sensori-motor control and learning, outlining contemporary scientific issues. The second part is dedicated to the haptic function which is subserved to the somatosensory system. The sensory and motor aspects of this system are intimately intertwined at all levels of the physical and neural organization of organisms. With a view to train students to adopt empirically-grounded methods in the study of the haptic function --- and of its deficits --- the course utilizes a multidisciplinary approach to expose them to the basic properties of the mechanics of tissues, to principles of neural organization and behavioral findings that concern its sensory and motor aspects. This course provides the students with an opportunity to apply state-of-the-art methods in a concrete experimental setting. It includes a practical part where students replicate basic results in sensorimotor human performance and Learning, and are exposed to a series of haptic illusions illustrating the theory. There is also one of several site visits where students can experience electromechanical equipment to exercise the haptic function. After attending the course, students are able to take part to a research project at the interface between robotics and modelling activities in life sciences.

b) Content

Motor aspects :

The organization of movement: issues, observations, concepts and models
Mathematics of control, Motor control, Motor Learning
Muscle mechanics and control
Single-joint systems, Multi-joint multi-muscle kinematics, Multi-joint dynamics and control
Learning in the presence of unstable dynamics & noise, Motion planning, Learning in decision making

Sensory aspects:

Elements of biomechanics (extremities muscles)
Elements of anatomy and neuroanatomy
Peripheral sensory organs (neural coding)
Principles of movement organization
Sensory thresholds; integrative perceptual functions (shape, texture, weight, length, space)
Illusions and crossmodal effects
Case study: prehension

c) Pre-requisites

General engineering background especially mechanics, continuum mechanics, signals, systems and control. Some Matlab programming ability will be required to realize the project.

d) Evaluation

In class tests, final exam, reasoned report on research papers, Project evaluation

e) References

Course notes by V. Hayward, Introduction to haptics
Course notes by E. Burdet, Human robotics: neuromechanical control and learning
Research papers compendium
Shadmehr R, Wise SP (2005) Computational Neurobiology of Reaching and Pointing: A Foundation for Motor Learning. Cambridge, MA: MIT Press.
Arbib MA (2002) The Handbook of Brain Theory and Neural Networks, 2nd ed. Cambridge, MA: MIT Press.
Bryson AE (1999) Dynamic Optimization. Englewood Cliffs, NJ: Prentice-Hall.
Sutton RS, Barto AG (1998) Reinforcement Learning: An Introduction. Cambridge, MA: MIT Press.

Teaching method

In class work	Total time	Weekly hours	Enrollment
Lectures	38 h		
Tutorials			
Practical work	8 h		
Project	14 h		