



UNIVERSITÀ  
DEGLI STUDI DI MILANO-BICOCCA

## COURSE SYLLABUS

### Motor Control

2425-1-I0201D131-I0201D196M

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#### Aims

Study of the principles of sensorimotor control and of the involved neural structures

#### Contents

Computational principles of sensorimotor control  
Sensorimotor learning  
Involved neural structures

#### Detailed program

##### Introduction to sensorimotor control

Marr Marr's levels of analysis  
Planning and control  
Direct and inverse kinematics  
Direct and inverse dynamics

##### Control schema and prediction

Feedforward e feedback control  
Internal models (inverse e forward)  
State estimation  
Bayesian inference

##### Optimality

Trajectory planning  
Cost functions: minimum jerk, minimum torque, minimum variance  
Optimal feedback control  
Minimum intervention principle

### **Sensorimotor learning**

Adaptation  
Task e prediction error

### **Cerebellum**

Functions  
Cerebellar microcircuit  
Cerebellar learning

### **Motor cortical regions**

Primary motor cortex  
Premotor cortex  
Descendent pathways

### **Spinal circuitry**

Spinal cord  
Muscle proprioceptors  
Spinal reflexes and their modulation

### **Control of locomotion**

Central Pattern Generator (CPG)  
CPG modulation by sensory afferents and sovraspinal regions

## **Prerequisites**

Neuroanatomy basic knowledge

## **Teaching form**

7 Standard teaching (2h/each) in presence: topics are discussed by the teacher in the classroom  
Integrated teaching in presence: students will perform presentations to deepen the topics proposed by the teacher (2 hours).

## **Textbook and teaching resource**

This course has been developed based on two books and several scientific articles. The teaching resources specific for each topic will be communicated during the classes.

### **Textbooks:**

Kandel E., et al. (2021). Principles of Neural Science. (6th ed). McGraw Hill. Capitoli 30-36.  
Purves D., et al. (2021). Neuroscienze. (5th ed. italiana; 6th ed. americana). Zanichelli. Capitoli 16-19.

**Scientific papers (required):**

Marr D. (2010) Vision: A Computational Investigation Into the Human Representation and Processing of Visual Information. The MIT Press. Capitolo 1.  
Wolpert D, Ghahramani Z. (2000). Computational principles of movement neuroscience. Nat Neurosci. Nat Neurosci 3 (Suppl 11), 1212–1217.  
Kawato M. (1999). Internal models for motor control and trajectory planning. Curr Opin Neurobiol. 9(6):718-27.  
Todorov E. (2004). Optimality principles in sensorimotor control. Nat Neurosci. 7(9):907-915.

**Scientific papers (suggested):**

Körding KP, Wolpert DM. (2004). Bayesian integration in sensorimotor learning. Nature. 427(6971):244-7  
Shadmehr R, Mussa-Ivaldi F. (1994) Adaptive representation of dynamics during learning of a motor task. JNeurosci. 14(4):3208-24  
Morasso, P. (1981) Spatial control of arm movements. Exp Brain Res 42, 223–227.  
Todorov E, Jordan MI. (2002). Optimal feedback control as a theory of motor coordination. Nat. Neurosci. 5(11):1226-1235.  
Shadmehr R, Krakauer JW. A computational neuroanatomy for motor control. Exp Brain Res. 2008 Mar;185(3):359-81

**Semester**

1st term

**Assessment method**

Described in the subject's syllabus

**Office hours**

By appointment  
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**Sustainable Development Goals**

GOOD HEALTH AND WELL-BEING | QUALITY EDUCATION | REDUCED INEQUALITIES

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