Dibris

ISTITUTO ITALIANO DI TECNOLOGIA

# PhD Courses offered (2019-2020)

# Outline of Courses

The offered courses can be roughly grouped into three distinct classes:

- Crossover courses oriented to scientific methodology, writing, results exploitation, and intellectual property protection.
- Foundation courses oriented to basic disciplines of robotics and bioengineering
- Specialty courses oriented to specific doctorate curricula.

In the following, the courses offered in each class by the doctorate are listed along the instructors and the number of credits.

## Crossover Courses

### Mandatory Courses (20 Credits)

| | | |
|---|---|---|
| Theatrical techniques for scientific presentation[1] | Sgorbissa | 6 |
| Ethics and Bioethics in bioengineering and robotics[1] | Battistuzzi | 6 |
| Research Methodology[1] | Cannata et al. | 3 |
| Grant writing[2] | Camurri | 5 |

### Recommended Courses

| | | |
|---|---|---|
| Legal Issues in bioengineering and robotics[2] | Di Gregorio | 3 |
| Intellectual Property[3,2] | Golda | 3 |
| Paper writing[1,3] | Marchese | 4 |

## Foundation Courses

### Programming

| | | |
|---|---|---|
| Introduction to Computer Programming for Researchers[4] (BASIC) | Goccia | 2 |
| C++ programming techniques | Solari/Chessa | 6 |
| Software Engineering for Robotics | Mastrogiovanni | 4 |
| Robot programming with ROS | Recchiuto | 6 |
| Modern C++ | Accame | 6 |

### Mechanical Design

| | | |
|---|---|---|
| Mechanical Drawing Fundamentals (BASIC) | Torazza | 2 |
| Computer aided design | Berselli | 5 |

### Modelling and Computational Methods

| | | |
|---|---|---|
| An introduction to spatial (6D) vectors and their use in robot dynamics | Featherstone | 4 |
| Computational Robot Dynamics | Featherstone | 5 |
| Introduction to physical human-robot interaction | Zenzeri | 5 |

[1] Recommended for 1st year students
[2] Recommended for 2nd and 3rd year students
[3] Course offered by the Doctorate in Electronics and Communications
[4] For non-engineers

| | | |
|---|---|---|
| Interaction in Virtual and Augmented reality | Chessa | 6 |
| Computational models of visual perception | Solari | 5 |
| Perceptual Systems | Gori/Tonelli | 5 |
| Regularization Methods for Machine Learning | Rosasco | 6 |

### Experimental Techniques and Data Analysis

| | | |
|---|---|---|
| Data acquisition and data analysis methods (BASIC) | Canali/Pistone | 2 |

## Specialty Courses

| | | |
|---|---|---|
| Advanced EEG analyses | Inuggi/Campus | 6 |
| Research oriented structural and functional neuroimaging | Inuggi/Greco | 6 |
| The 3Rs approach: Replacement, Reduction and Refinement of animal procedures in biomedical research | Pastorino | 4 |
| Modeling Neuronal Structures | Massobrio | 4 |

| | | |
|---|---|---|
| Nanophotonic devices: from fabrication to applications | Toma | 6 |
| Advanced optical fluorescence microscopy methods | Bianchini/Diaspro | 5 |
| Fluorescence Super-Resolution Microscopy: Basis, Applications and Perspectives | Vicidomini | 4 |
| Polymers for sustainability, food packaging and biomedics | Perotto/Papadopoulou/Suarato | 5 |
| Hybrid microfluidics systems for electronics, photonics, and sensors | Surdo | 4 |
| Principle of tissue engineering and regenerative medicine | Marrella | 5 |

| | | |
|---|---|---|
| Psycophysics Methods (BASIC) | Gori/Tonelli | 2 |
| Cognitive Robotics for Human-Robot Interaction | Rea/Sciutti/Vignolo | 6 |

| | | |
|---|---|---|
| Robotic technologies for sensorimotor rehabilitation | Morasso/Zenzeri | 6 |
| Robotic Virtual Prototyping Design | Cannella/D'Imperio/Romanelli | 6 |

# Theatrical techniques for Scientific Presentation

**Unit code**: ING-INF/05

**Scientific Disciplinary Sector:**

**Number of hours:** 12

**Credits:** 6

## AIMS AND CONTENT

**Learning Outcomes (short)**

Upon successful completion of this course, students will be able to successfully prepare a scientific presentation for a specific audience, and to deliver it to the public by using their voice, their body and the space around them in the most efficient way as possible.

### Syllabus/Content

Topics covered will include:

- How to prepare a presentation by taking into account the scientific context and the public;
- Structuring the presentation: the importance of the beginning and the end;
- Scientific journals and conferences;
- Theatrical techniques to use the space;
- Theatrical techniques to use the body;
- Theatrical techniques to use the voice.

## WHO

**Teacher(s):**

Antonio Sgorbissa, +393204218938, antonio.sgorbissa@unige.it

## HOW

**Teaching Methods:**

The course will be delivered using a range of teaching and learning methods, including lectures, group discussions and activities, as well as acting exercises to control the body, the voice, and the surrounding spaces.

**Assessment Methods:**

Students will be required to 1) prepare a presentation to be delivered to other students, and 2) participate to short theatrical performance to test the techniques they have learnt during lessons.

## WHERE AND WHEN

**Lesson Location**

@UNIGE: Aula Tagliasco Villa Bonino Viale F. Causa 13

**Lesson Schedule**

- February 4th 9:30-12:30
- February 11th 9:30-12:30
- February 12th 9:30-12:30
- February 25th 9:30-12:30

**Office hours for student**

Contact the teacher to fix an appointment.

**CONTACTS**

Via Opera Pia 13, Second Floor. Contact the teacher via phone and email.

# Ethics and Bioethics in Bioengineering and Robotics

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: MED02/MED43/IUS20/M-FIL03**

**Number of hours:** 15

**Credits:** 6

## AIMS AND CONTENT

**Learning Outcomes (short)**

Upon successful completion of this course, students will be able to

- explain some of the key ethical issues in bioengineering and robotics
- identify ethically problematic facets of a project
- apply an ethical decision-making framework to a scenario in order to determine an ethically appropriate course of action.

**Learning Outcomes (further info)**

*How can we develop models of human-robot interaction that preserve human values? Can ethical considerations be incorporated into the design of novel artifacts? What duties and obligations do researchers have towards research participants?*

Increasingly, researchers and professionals in the fields of bioengineering and robotics are faced with ethical questions like these. The goal of this course is therefore twofold: first, to develop PhD students' sensitivity to the ethical issues that arise in research and professional practice, and, second, to provide them with the knowledge and tools that will help them navigate ethically complex scenarios and reach ethically appropriate decisions.

**Syllabus/Content**

Topics covered will include:

- Ethics and bioethics: concepts and frameworks
- Ethical decision-making
- The requirements of ethical research
- Research protocols and ethical review
- Informed consent
- Personal data and privacy
- Value Sensitive Design

The reading list will be provided after the first session.

## WHO

**Teacher(s):** Linda Battistuzzi, tel. 010353 – 2801, e-mail: linda.battistuzzi@unige.it.

## HOW

### Teaching Methods

The course will be delivered using a range of teaching and learning methods, including lectures and group discussions and activities. Case-Based learning, an approach to learning and instruction that uses factual or fictional scenarios exemplifying the issues at hand, will be extensively used.

### Exam Description

Students will be asked to develop an ethically problematic case of their own, explaining the issues it raises and proposing an ethically appropriate course of action.

### Assessment Methods

Students will present their cases during class for group discussion.

## WHERE AND WHEN

### Lesson Location

UNIGE.

### Lesson Schedule

9:30 – 12:30 on February 3, 10, 18, 24 and March 3.

### Office hours for student

I can generally be reached by email. Appointments can be organized if necessary.

## CONTACTS

Students should contact me by email.

# Legal issues in Bioengineering and Robotics

## Bioengeneering, A.I. and Robotics: applicable law, liability and contract.

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: IUS/01 IUS/02 IUS/05 IUS/17**

**Number of hours:** 6

**Credits:** 3

**AIMS AND CONTENT**

**Learning Outcomes (short)**

At the end of the course the students will be able to:

- get aquainted with the basic legal issues linked to the new technologies, A.I. and robotics areas
- enhance the knowledge of the European and Italian Law liability rules in relation to the producer, the designer and the seller.
- learn when, why, how to make a project in compliance with applicable law.
- be aware of the legal effects in order to make a decision.

**Learning Outcomes (further info)**

*How can we develop models of human-robot interaction that respect the law principles? How can set forth the liability for damages? Who does bear the relevant risks? Which kind of contracts can we provide?*

Researchers and professionals in bioengineering, A.I. and robotics areas deal with legal questions like these. The course aims to: develop PhD students' ability to identify legal issues that could arise in research and professional practice and provide them with the knowledge and tools that will sort out legal problems in the complex scenarios and reach appropriate decisions.

**Syllabus/Content**

Topics covered will include:

- Basic concepts of European and National law
- Knowledge of legal issues
- Product Liability and Consumer Protection
- Data Protection (GDPR)
- General Principles of Contract Law and Intellectual Property Law
- Case studies

The reading list will be provided after the first session.

**WHO**

**Teacher(s): Valentina Di Gregorio**, tel. 0102099911, e-mail: valentina.digregorio@unige.it.

## HOW

### Teaching Methods

The course will be delivered using a range of teaching and learning methods, including lectures, group discussions, activities and case studies.

### Exam Description

Students will be asked to obtain the ability in identify potential legal issues and to solve them in order to avoid negative effects on the project.

### Assessment Methods

Students will describe their case in a short report (1000-1500 words).

## WHERE AND WHEN

### Lesson Location

DIBRIS (UNIGE).

### Lesson Schedule

### Office hours for student

I can generally be reached by email. Appointments can be organized if necessary.

## CONTACTS

Prof. Valentina Di Gregorio

Email: valentina.digregorio@unige.it

# Introduction to Computer Programming for Researchers

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** INF/01

**Number of hours:** 15 hours

**Credits:** 2 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course will take the students with no or minimal prior experience of programming through the main principles and best practices of programming. The course is intended for researchers who wish to learn the Python programming language.

**Learning Outcomes (further info)**

The course is suitable for students who have minimal or no programming experience. It will introduce the fundamental programming structures, and it will also cover some central mechanisms of object-oriented programming techniques. The course will also include an introduction to testing and debugging code techniques. During the course there will be practical exercises.

**Syllabus/Content**

- Overview of the fundamental programming structures: primitive data types, constants, variables, operators, functions, strings.
- Classes and objects: OOP principles, class variables and methods, abstraction, inheritance, polymorphism.
- Introduction to good programming techniques.
- Testing and debugging code.
- Practical exercises

## WHO

**Teacher(s):** name, phone number, email

Marcello Goccia, Tel. (+39) 010 8172 216, email: marcello.goccia@iit.it

## HOW

**Teaching Methods**

Frontal lessons with practical exercises. The students need to bring their laptop for the practical exercises.

**Exam Description**

There will be a final examination decided by the instructor.

**Assessment Methods**

According to the frequency of the course and the success in the examination.

## WHERE AND WHEN

**Lesson Location**

Istituto Italiano di Tecnologia, Via Enrico Melen 83, Building B, Genova

**Lesson Schedule**

January 8-10-13-15-17

**Office hours for student**

Students can send e-mail.

## CONTACTS

Teacher's office is in:

Center for Human Technologies

Fondazione Istituto Italiano di Tecnologia (IIT)

Via Enrico Melen 83, Genova, Italy

Tel. (+39) 010 8172 216

# C++ programming techniques

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: INF/01**

**Number of hours:** 18 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

This course introduces the specificities of C++ object oriented programming language and focuses on the use of C++ for the implementation of object-oriented software modules. In particular, programming techniques to tackle the issues of memory management, robustness and efficiency are considered.

**Learning Outcomes (further info)**

**Syllabus/Content**

- Basic Facilities: The C and C++ languages: pointers, arrays, and structures. Functions. Namespaces and exceptions.
- Abstraction Mechanisms: Classes and objects. Operator overloading. Class hierarchies. Polymorphism. Templates.
- Case studies: Containers and algorithms. Iterators.

## WHO

**Teacher(s):**

Fabio Solari, fabio.solari@unige.it, +39 010 3536756

Manuela Chessa, manuela.chessa@unige.it, +39 010 3536626

## HOW

**Teaching Methods**

Classroom lectures with theory and examples.

**Exam Description**

The exam will consist in the development of a specific software module/application.

**Assessment Methods**

Discussion about the implemented software module. A short document describing the application is required.

## WHERE AND WHEN

**Lesson Location**

@UNIGE (DIBRIS, via Dodecaneso 35)

**Lesson Schedule**

3-4-5-8-9-10 June 2020, each morning h 10-13

**Office hours for student**

The teachers will be available on appointment (fabio.solari@unige.it  manuela.chessa@unige.it)

## CONTACTS

Email: fabio.solari@unige.it

Office: Valletta Puggia - Via Dodecaneso 35, 3rd floor, room 303, 16146 Genova - ITALY

Phone: +39 010 353 6756

Email: manuela.chessa@unige.it

Office: Valletta Puggia - Via Dodecaneso 35, 2nd floor, room 226, 16146 Genova - ITALY

Phone: +39 010 353 6626

# Software Engineering for Robotics

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-INF/05**

**Number of hours:** 9

**Credits:** 4

## AIMS AND CONTENT

**Learning Outcomes (short)**

The main objective of Software Engineering for Robotics (SER) is to explore advanced, state of the art, topics for the development of software powering current- and next-generation robots. Students will learn how to define requirements, formalize specifications, organize the software architecture's structure, and design testing and benchmarking criteria.

**Learning Outcomes (further info)**

The availability nowadays of advanced middleware solutions to develop complex robot architectures requires robot engineers to broadly reason about how to design, organize, and validate such architectures. SER explores advanced concepts in software engineering and architectures to provide students with important conceptual tools. SER explores methodologies for software engineering workflows, software project management, formal methods in design and design patterns for robot-related software, testing methodologies.

**Syllabus/Content**

The course is organize in four modules:

1. Workflow models in software engineering, i.e., waterfall, iterative waterfall, spiral, incremental, RAD, agile, XP, V, as well as architectural models, i.e., coupling and cohesion, life cycles, PNZ model, SW reliability model.
2. Software project management, i.e., size estimation, COCOMO model, CMM, risk management, quasi renewal processes, reliability models.
3. Software requirements processes, robot-related design patterns, e.g., adapters, communication patterns, stored-interface, etc.
4. Principles of software testing, i.e., black box, white box, debugging, integration.

## WHO

**Teacher(s):**

Prof. Fulvio Mastrogiovanni

Email: fulvio.mastrogiovanni@unige.it

## HOW

**Teaching Methods:**

The course will exploit mainly frontal classes, interleaved with moments when all the students will be involved in discussions. Study material will be based on slides and by relevant scientific papers provided by the lecturer.

**Exam Description:**

On the basis of real-world problems provided by the lecturer, students will be required to develop a full specification, design, and testing document on the basis of the notions learned during the classes. Students will be provided with a template to fill.

**Assessment Methods:**

Assessment will be based on a discussion of the produced document.

## WHERE AND WHEN

**Lesson Location**

All classes will be held at the Department of Informatics, Bioengineering, Robotics, and Systems Engineering, University of Genoa, Via Opera Pia 13, 16145, Genoa.

**Lesson Schedule**

Classes are scheduled as follows:

1. March 4, 2020, 9:00-12:00, "Aula Viola" room.
2. March 5, 2020, 9:00-12:00, "Aula Viola" room.
3. March 6, 2020, 9:00-12:00, "Aula Viola" room.

**Office hours for student**

The teacher is available for appointments by email.

## CONTACTS

Fulvio Mastrogiovanni can be found:

- in his office at the Department of Informatics, Bioengineering, Robotics, and Systems Engineering, Villa Bonino, Viale Causa 13, 16145, Genoa;
- in EMAROlab, Viale Causa 18, 16145, Genoa.

The teacher is available for appointments by email.

# Robot programming with ROS

**Unit code**:

**Scientific Disciplinary Sector:** ING-INF/05

**Number of hours:** 15 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

- Learning and understanding the ROS communication architecture.
- Integrating algorithms for planning and perception within the ROS framework
- Applying the ROS navigation stack to enable autonomous mobile robot navigation.
- Simulating robot models in real physics environments

**Learning Outcomes (further info)**

ROS is a robotic middleware which offers a collection of packages for commonly used functionality, low level control, hardware abstraction and message passing. Given all these aspects, it has become a standard in robotics. The course will explore its most relevant functionalities, with the help of different examples, analyzing how the ROS framework may help in solving common problems in robotics, such as model simulation, localization and mapping, motion planning. The course will foresee the usage of some commonly used robotic simulators, such as Gazebo and VREP, giving the possibility of practically testing the ROS features. During the course, the students will be working with their own standalone Ubuntu-Linux installation.

**Syllabus/Content**

- Class I (C1) (3 hours) - Introduction to ROS Topics, Services, Actions, and Nodes. Class examples.
- Class II (C2) (3 hours) - Software representation of a Robot using Unified Robot Description Format (URDF), ROS parameter server and adding real-world object representations to the simulation environment. Simulating a robot model with Gazebo. Class examples. Assignment I
- Class III (C3) (3hours) - Map creation with GMapping package, autonomously navigate a known map with ROS navigation, analysis of the OctoMap package. Class examples.
- Class IV (C4) (3 hours) – The robotic simulator VRep and its interface with ROS. Class examples. Assignment II
- Class V (C5) (3 hours) –Different robots (drones, wheeled robot, humanoids,…), ROS and simulators. Class examples and real applications.

## WHO

**Teacher(s):** Dr. Carmine Tommaso Recchiuto, +390103532801, carmine.recchiuto@dibris.unige.it

## HOW

**Teaching Methods.** The teaching methodology will combine lectures together with supervised exercises that will address all most relevant theoretical aspects. Slides of the course will be provided before each lecture. Two mandatory assignments will be given at the end of the 2nd and of the 4th lecture.

**Exam Description.** The assignments will consist on the implementation of robotic simulations based on software written using the ROS framework. Simulation environments will be shown during the courses. The students will be required to write some ROS nodes, re-use existing ROS packages and create/modify robotic models for the simulation. The final exam will consist on an oral discussion about the implementation of the assignments.

**Assessment Methods.** The teachers will assess the appropriateness of the code and the effectiveness of the simulations. The students will present their work during an oral examination, after making an appointment with the teacher. The assessment will take in consideration how the students have learnt, selected and implemented the techniques shown during the course.

## WHERE AND WHEN

**Lesson Location**

@UNIGE.

**Lesson Schedule**

Wednesday 26 Feb 2020, 10:00-13:00

Wednesday 4 Mar 2020, 10:00-13:00

Wednesday 11 Mar 2020, 10:00-13:00

Wednesday 18 Mar 2020, 10:00-13:00

Wednesday 25 Mar 2020, 10:00-13:00

**Office hours for student**

The teacher may be contacted by mail or by phone (see contacts)

## CONTACTS

Dr. Carmine Tommaso Recchiuto, Postdoctoral Research Fellow, Laboratorium (DIBRIS, E building 2nd floor)

Phone: +390103532801

Mail: carmine.recchiuto@dibris.unige.it

# Modern C++

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-INF/04 OR ING-INF/05 OR ING-INF/06**

**Number of hours:** 15

**Credits:** 6

## AIMS AND CONTENT

**Learning Outcomes (short)**

The students will learn the new syntax and philosophy of Modern C++ (releases C++11, -14, -17).

**Learning Outcomes (further info)**

Left intentionally empty.

**Syllabus/Content**

Each of the following modules will be 2.5 hours each

1. Introduction: presentation of the course, refresh of C++98.
2. The basics: nullptr, auto, type aliases, initializer list, uniform initialization
3. The basics: range based loops, constexpr, scoped enums, override and final.
4. Advanced topics: move semantics, smart pointers
5. Advanced topics: lambda functions, STL containers, algorithms
6. Advanced topics: concurrency

## WHO

**Teacher(s):**

Marco Accame

+39 010 2898201

marco.accame@iit.it

## HOW

**Teaching Methods:**

Slides with code examples, exam simulation, open discussion and questions.

There is a maximum of 16 students. This limit is due to the reduced capacity of the available rooms.

Hence, it is recommended to all students who have an interest in the course to contact the teacher via email by the date of 15 Dec 2019. The participant list will be frozen by 31 Dec 2019.

**Exam Description:**

Two sets of tests: one for the basics and one for the advanced topics.

**Assessment Methods:**

The be admitted to each test one must have followed the lessons of the relevant group. It is possible to miss at most one lesson per group.

PASS if 50% of answers are correct, FAIL otherwise.

## WHERE AND WHEN

**Lesson Location**

@ IIT-CRIS (Sala Cassini).

**Lesson Schedule**

1. Introduction: on 14 Jan 20, 1400-1630
2. The basics 1: on 16 Jan 20, 1400-1630
3. The basics 2 + test regarding modules 1, 2, 3: on 21 Jan 20, 1400-1630
4. Advanced topics 1: on 23 Jan 20, 1400-1630
5. Advanced topics 2: on 28 Jan 20, 1400-1630
6. Advanced topics 3 + test regarding modules 4, 5, 6: on 30 Jan 20, 1400-1630

**Office hours for student**

0900-1700 Monday to Friday.

## CONTACTS

Place: First floor of IIT-CRIS (Center for Robotics and Intelligent Systems), Via San Quirico 19D, 16163 Genova, Italy.

Preferred interaction modes:

- email with subject beginning with the string “[ADV-C++]”,
- phone
- face to face after arranged appointment.

# Mechanical Drawing Fundamentals

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** ING-IND/15

**Number of hours:** 18 hours

**Credits:** 2 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

This course provides an introduction to Mechanical Technical Drawing with mention to manufacturing techniques. The aim of the course is to give a base knowledge in understanding and preparing mechanical technical drawings, so there is no need of prior background of mechanical drawing.

**Learning Outcomes (further info)**

Mechanical drawing is the main way to communicate design need to technicians, workshops, suppliers. A base knowledge of rules and methods helps the researcher, even if not directly engaged in mechanical design, to better contribute to interdisciplinary team working when involved in the design of experimental setups, scientific devices, and the writing/understanding of technical specifications.

**Syllabus/Content**

- **Introduction** (projection methods and orthogonal projections theory)
- **Technical Drawing Rules** (lines rules, sections, dimensioning)
- **Drawing for manufacturing** (proper dimensioning and prescriptions according to production method)
- **Tolerances and surface finish** (dimensional and geometrical tolerances, roughness)
- **Representation of main removable and non-removable connections** (welds, threads)

## WHO

**Teacher(s):** Diego Torazza, +39 010 2897 231, Diego.Torazza@iit.it

## HOW

**Teaching Methods:** Frontal lessons with projected slides

**Exam Description:** Written test with multiple answer questions

**Assessment Methods:** In order to obtain the 6 CFU students need to be present at minimum 15 hours of lessons and successfully pass the written test.

## WHERE AND WHEN

**Lesson Location**

Istituto Italiano di Tecnologia, Via E. Melen 83, Building B, Genova. Room to be defined.

**Lesson Schedule**

Tuesday, 7th April 2020, 9-12

Friday, 10th April 2020, 9-12

Tuesday, 14th April 2020, 9-12

Friday, 17th April 2020, 9-12

Tuesday, 21th April 2020, 9-12

Friday, 24th April 2020, 9-12

**Office hours for student**

The teacher is available on appointment by phone/mail.

**CONTACTS**

Teacher's office is located in:

Center for Human Technologies

Fondazione Istituto Italiano di Tecnologia (IIT)

Via E. Melen 83, Building B, 7th floor, Genova, Italy

+39 010 2897 231, Diego.Torazza@iit.it

# Computer Aided Design

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-IND/15**

**Number of hours:** 12 hours

**Credits:** 5 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The aim of the course is to gain and apply knowledge of advanced CAD concepts and techniques by using high-end CAD systems (i.e. *PTC Creo*).

**Learning Outcomes (further info)**

The course deals with the main CAD modeling techniques to develop the virtual model (DMU) of complex industrial products. The main topics are: 3D parametric and explicit modeling, feature modeling, surface modeling, geometric drawings, assembly modelling, parametric expressions and curves. Tolerances. Manufacturing drawings. Sheet Metal Technology. Basic stress and dynamic analysis.

**Syllabus/Content**

- Main geometry representation schemes: 2D and 3D mathematical models (Vertex, Line, Surface, Solid, Assembly), main models for geometry exchange (IGS, STP, STL).
- Solid modeling CSG and B-Rep: main features of 3D CAD modelers, sketch-based modelers, parametric modeling, the concept of history-based modeling, feature-based modeling.
- Assembly-based modeling: top-down setting bottom-up; use of part skeleton and assembly; structuring of an assembly; flat and/or sub-assemblies and implications in project management.
- Modeling aimed at the product concept: continuous curvature parametric curves, double curvature surfaces (free-form) based on curves, modeling of surfaces from edge curves, modeling of path-based surfaces and the concept of sweeps.
- Direct modeling: management of the history-free models
- Geometry preparation techniques for structural simulations. Basic simulations with integrated tools (*Creo Mechanisms and Creo Simulate*).

## WHO

**Teacher(s):**

| | | |
|---|---|---|
| Giovanni Berselli | 010 33 52839 | giovanni.berselli@unige.it |
| Pietro Bilancia | 0103352839 | pietro.bilancia@edu.unige.it |

## How

**Teaching Methods:**

The course will be based on 3 hands-on lectures. Slides of the course will be provided before each lectures. No previous knowledge of any CAD system is required.

**Exam Description:**

The assessment of learning takes place through a practical test (project) in a computer lab. The test involves the use of the CAD system to develop a parametric DMU of a simple mechanical system (proposed by either the lecturers or the students).

**Assessment Methods:**

Discussion about the implemented application. A small document describing the application is required. The developed 3D CAD model will be released to the lecturer for correction and proof-reading.

## Where and When

**Lesson Location**

@UNIGE (Villa Cambiaso) room Infal 2 (contact the teacher for room confirmation)

**Lesson Schedule**

8-9-10 June 2020 h9-13 room Infal 2.

**Office hours for student**

The teacher will be available on appointment (giovanni.berselli@unige.it)

## Contacts

Email: giovanni.berselli@unige.it

Office: DIME - Sezione MEC - First floor - Left Corridor, Via all’Opera Pia 15/A - 16145 Genova (ITALY)

Phone: +39 010 33 52839

# An Introduction to Spatial (6D) Vectors and Their Use in Robot Dynamics

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** ING-INF/04

**Number of hours:** 10

**Credits:** 4

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course provides an introduction to spatial vector algebra, which is a tool that simplifies the task of solving problems in rigid-body dynamics by reducing the quantity of algebra needed to describe and solve a problem, and reducing the amount of computer code needed to calculate the answer.

**Learning Outcomes (further info)**

Spatial vectors combine the linear and angular aspects of rigid-body motion, so that a single spatial vector can provide a complete description of a rigid-body's velocity, acceleration, momentum, or the forces acting upon it. The result is a large reduction in the quantity of algebra needed to describe and solve a problem in rigid-body dynamics: fewer quantities, fewer equations, and fewer steps to the solution. There is also a large reduction in the quantity of computer code needed to calculate the answer. This course explains spatial vectors in sufficient detail to allow students to understand what they are, how they work, and how to use them in their own research.

**Syllabus/Content**

- motion and force
- Plucker coordinates
- differentiation and acceleration
- equation of motion
- motion constraints

**Prerequisites**: A basic knowledge of Newtonian dynamics is required (i.e., dynamics using 3D vectors), such as can be obtained from a first course in dynamics at undergraduate level. A basic knowledge of linear algebra is also required (vector spaces and subspaces, bases, coordinates, linear independence, range and null spaces of a matrix, etc.)

## WHO

**Teacher:** Roy Featherstone, roy.featherstone@iit.it

## HOW

### Teaching Methods

The course will be taught by means of lectures and class exercises. Lecture notes will be provided, as well as supplementary materials for self-study.

### Exam Description

There will be an oral exam based on the lecture material.

### Assessment Methods

The course will be assessed by oral exam only. Students wishing to take the exam must make an appointment with the teacher.

## WHERE AND WHEN

### Lesson Location

IIT (via Morego).

### Lesson Schedule

Four 2.5-hour sessions in the afternoon from Monday 9th to Thursday 12th March inclusive.

### Office hours for students

The teacher is available at most times and on most days to answer students' questions face-to-face or by email. No appointment is required.

## CONTACTS

The teacher's office is located on the 4th floor, IIT Morego, near the toilets. Students can contact him via email: roy.featherstone@iit.it

# Computational Robot Dynamics

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** ING-INF/04

**Number of hours:** 12

**Credits:** 5

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course covers the fundamentals of computational robot dynamics: dynamic models of robots; inverse, forward and hybrid dynamics; and the process of dynamics simulation.

**Learning Outcomes (further info)**

Most dynamics simulation today is performed by specialized 'black-box' simulators that hide the details from the user. Unfortunately, many of these simulators are inaccurate, buggy, or suffer from a variety of limitations. This course provides students with the necessary knowledge to become competent users (and producers) of dynamics software. Topics range from equations of motion through to model-based dynamics algorithms and techniques for accurate and reliable simulation.

**Syllabus/Content**

- basic equations of motion
- inverse dynamics, and the idea of a recursive algorithm
- efficient implementation of spatial vector arithmetic
- forward and hybrid dynamics
- dynamic models of robots
- the integration process

**Prerequisites**: It is desirable, but not necessary, that students take the preceding course on spatial vectors. Students who have not taken this course should nevertheless have a basic knowledge of classical Newtonian dynamics (i.e., dynamics using 3D vectors).

## WHO

**Teacher:** Roy Featherstone, roy.featherstone@iit.it

## HOW

**Teaching Methods**

The course will be taught by means of lectures, class exercises and practical exercises using the software package *spatial_v2*. Students will need access to Matlab and Simulink in order to run this software. Lecture notes will be provided.

**Exam Description**

There will be an oral exam based on the lecture material and exercises.

**Assessment Methods**

The course will be assessed by oral exam only. Students wishing to take the exam must make an appointment with the teacher.

## WHERE AND WHEN

**Lesson Location**

IIT (via Morego).

**Lesson Schedule**

Four 3-hour sessions in the afternoon from Monday 23rd to Thursday 26th March inclusive.

**Office hours for students**

The teacher is available at most times and on most days to answer students' questions face-to-face or by email. No appointment is required.

## CONTACTS

The teacher's office is located on the 4th floor, IIT Morego, near the toilets. Students can contact him via email: roy.featherstone@iit.it

# Introduction to physical Human-Robot Interaction

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-INF/06**

**Number of hours:** 12 hours

**Credits:** 4 CFUs

## AIMS AND CONTENT

**Learning Outcomes (short)**

The present course will introduce the field of physical Human-Robot Interaction (pHRI). It will discuss current scientific and technological limitations in collaborative scenarios and methods to deal with them. Emphasis will be given to the integration of knowledge between neuroscience and robotics.

**Learning Outcomes (further info)**

Robotic technology is rapidly developing, and seemingly offers a multitude of potential near-future applications. We see robots as embodied artificial intelligence (AI), and although AI is progressing rapidly in many areas, generating efficient movement and physical interaction is still a major challenge, especially when it comes to human-like movement and interaction with humans. In line with these considerations, in the next years the field of physical human-robot interaction will be extensively studied both from human and robot side. Specific robots will be designed to cooperate with humans in different contexts such as assisted industrial manipulation, virtual training, entertainment or rehabilitation.

The first part of the course will introduce basic concepts on how the brain control movements in humans and how it is possible to design robot control strategies for interacting robots. In the second part of the course will be presented findings in collaborative scenarios both from robot and human perspective.

**Syllabus/Content**

- The concept of physical human robot interaction
- Human motor control strategies and mechanisms
- Robot control in pHRI: Compliance control, Impedance control, Force control
- Human motor skill learning during haptic interaction
- Robot learning algorithms in collaborative contexts
- Laboratory

## WHO

**Teacher:** Jacopo Zenzeri, 3408311387, jacopo.zenzeri@iit.it

## HOW

**Teaching Methods**

For the theory lessons, slide presentation and discussion of a reading list

For the lab activity direct involvement in experiment planning and data processing

No Prerequisites

Reading List: Specific readings will be assigned for each class.

**Exam Description**

There will be a final examination decided by the instructor and communicated to the students at the beginning of the course, after contacting the students and evaluating their background.

**Assessment Methods**

The assessment method will be decided by the instructor and communicated to the students at the beginning of the course.

## WHERE AND WHEN

**Venue**

Istituto Italiano di Tecnologia, Campus Erzelli (Via Melen 83, Bldg B, 16152 Genova)

**Course dates & Schedule**

Campus Erzelli: 8 hours (theory), 9-10-11-12 March 2020, time 9-11, (10th floor - room to be decided 1 month in advance)

Campus Erzelli: 4 hours (lab); 13 March 2020, time 9-13, MLARR lab (7th floor)

**Office hours for student**

Appointments by email request

## CONTACTS

Jacopo Zenzeri, IIT Campus Erzelli, 7th floor, 3408311387, jacopo.zenzeri@iit.it

# Interaction in Virtual and Augmented Reality

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: INF/01**

**Number of hours:** 20 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course will present the fundamentals of the design, implementation and assessment of virtual (VR) and augmented reality (AR) environments, and the techniques to interact within such environments. Particular attention will be paid to the perceptual issues and to the ecological interaction in VR and AR.

**Learning Outcomes (further info)**

**Syllabus/Content**

- Introduction to VR and AR: techniques and devices
- Immersivity, presence, quality of experience, and adverse symptoms: study and evaluation.
- Interaction in VR and AR: devices and software solutions. Techniques for ecological interaction.
- Perceptual issues when acting in virtual and augmented reality.
- Examples and case studies

## WHO

**Teacher(s):** Manuela Chessa, manuela.chessa@unige.it, +39 010 3536663

## HOW

**Teaching Methods**

Classroom lectures with theory and examples.

**Exam Description**

The exam will consist in the development of a simple virtual or augmented reality application, or in the design and execution of an experimental session to test some of the issues presented during the course.

**Assessment Methods**

Discussion about the implemented application or the about results of the experiment. A small document describing the application or the experiment is required. The developed code should be released to the teacher.

## WHERE AND WHEN

**Lesson Location**

@UNIGE (Valletta Puggia) room 217 (contact the teacher for room confirmation)

**Lesson Schedule**

27-28-29-30-31 January 2020 h 9-13 room 217

**Office hours for student**

The teacher will be available on appointment (manuela.chessa@unige.it)

## CONTACTS

Email: manuela.chessa@unige.it

Office: Valletta Puggia - Via Dodecaneso 35, 3rd floor, room 329, 16146 Genova - ITALY

Phone: +39 010 353 6663

# Computational models of visual perception

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: INF/01**

**Number of hours:** 12 hours

**Credits:** 5 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

This course introduces paradigms and methods that allow students to develop computational models of visual perception, which are based on hierarchical networks of interacting neural units, mimicking biological processing stages.

**Learning Outcomes (further info)**

**Syllabus/Content**

- Introduction to visual perception and to the cortical dorsal and ventral streams for action and recognition tasks.
- Hierarchical networks of functional neural units. Computational models of the visual features estimation for action and recognition. Comparison among computational models and computer vision algorithms. Benchmark Datasets. How to use computational models to improve virtual and augmented reality systems to allow natural perception and interaction.
- Case studies: models and algorithms of the literature.

## WHO

**Teacher(s):**

Fabio Solari, fabio.solari@unige.it, +39 010 3536756

## HOW

**Teaching Methods**

Classroom lectures with theory and examples.

**Exam Description**

The exam will consist in the analysis/development of a specific neural model.

**Assessment Methods**

A discussion about the implemented model and a short document, which describes the analysis and implementation, are required.

## WHERE AND WHEN

**Lesson Location**

@UNIGE (DIBRIS, via Dodecaneso 35)

**Lesson Schedule**

*To be synchronized with the PhD program in Computer Science and Systems Engineering*

**Office hours for student**

The teachers will be available on appointment (fabio.solari@unige.it )

## CONTACTS

Email: fabio.solari@unige.it

Office: Valletta Puggia - Via Dodecaneso 35, 3rd floor, room 303, 16146 Genova - ITALY

Phone: +39 010 353 6756

# Perceptual systems

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** M-PSI/01

**Number of hours:** 12

**Credits:** 5 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

Students will learn how the functioning of the main sensory systems, i.e. vision, audition and touch. Moreover, it will be explain the process of multisensory integration and cross-modal interaction.

**Learning Outcomes (further info)**

From birth, we interact with the world through our senses and movements. How the brain process and transform sensory signals into perceptions and motor output is one of the main questions in the field of experimental psychology. The goal of the course is to present the perceptual and motor systems from the anatomical, physiological and functional points of view. A particular focus will be on how physical stimuli are transduced into sensory signals by our peripheral sensory apparatus, as well as how the motor hierarchy organize complex behaviour. In the last part of the course, these topics will be described in relation with cross-sensory interaction and multisensory integration in the adult and the developing brain.

**Syllabus/Content**

Class 1 (3 hours): Visual system I.
Class 2 (2 hours): Visual system II and Motor system.
Class 3 (3 hours): Audition and touch
Class 4 (2 hours): Multisensory integration and Cross-modal interaction.
Class 5 (2 hours): Final Exam.

## WHO

**Teacher(s):**

Monica Gori – Istituto Italiano di Tecnologia – +39 0108172217, monica.gori@iit.it

Alessia Tonelli – Istituto Italiano di Tecnologia – +39 0108172232, alessia.tonelli@iit.it / tonelli.alessia@gmail.com

## HOW

**Teaching Methods:**

Frontal lessons and presentations.

**Exam Description:**

The exam will consist of a multiple-choice questionnaire, which must be completed in one hour.

**Assessment Methods:**

In order to obtain the 4 CFU, students have to answer correctly at least at the 60% of the questions.

## WHERE AND WHEN

**Lesson Location**

The lessons will be held at IIT – Erzelli. The name of the room depends on availability and will be communicated in advance

**Lesson Schedule**

The course will be held in mid September 2020. Each class will last 2/3 hrs.

**Office hours for student**

Students enquires about course content and organization should be sent by e-mail. Personal appointment shall be arranged when necessary.

## CONTACTS

Students can contact the teacher by email:

Monica Gori – monica.gori@iit.it

Alessia Tonelli – alessia.tonelli@iit.it or tonelli.alessia@gmail.com

# Regularization Methods for Machine Learning

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** ING-INF/04 OR ING-INF/05 OR ING-INF/06

**Number of hours:** 20

**Credits:** 6

## AIMS AND CONTENT

**Learning Outcomes (short)**

Students will learn the statistical foundations and the fundamental algorithms of Machine Learning, with a focus on regularization methods, and they will gain practical knowledge of all algorithms implementing them in parallel laboratory sessions.

**Learning Outcomes (further info)**

**Syllabus/Content**

Introduction to Statistical Machine Learning, Tikhonov Regularization and Kernels, Binary classification and model selection, Early Stopping and Spectral Regularization, Regularization for Multi-task Learning, Spectral filters and multi-class classification, Sparsity Based Regularization, Structured Sparsity, Sparsity-based learning, Data Representation: Dictionary Learning, Data Representation: Deep Learning.

## WHO

**Teacher(s):**

Lorenzo Rosasco,

(+39) 010353 - 6607,

lorenzo.rosasco@unige.it

## HOW

**Teaching Methods:**

Theory classes and laboratory sessions

**Exam Description:**

Report on labs

**Assessment Methods:**

Report evaluation: passed / failed

## WHERE AND WHEN

**Lesson Location**

@ UNIGE

**Lesson Schedule**

Monday, June 29 - Friday, July 3

**Office hours for student**

by e-mail

## CONTACTS

Lorenzo Rosasco, room 201, phone (+39) 010353 - 6607, e-mail: lorenzo.rosasco@unige.it

course webpage: http://lcsl.mit.edu/courses/regml/regml2020/

# Data Acquisition and Data Analysis Methods

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-INF/04 OR ING-INF/05 OR ING-INF/06**

**Number of hours:** 15

**Credits:** 2

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course is aimed at students who intend to acquire knowledge to develop measurement systems and data analysis algorithms to be adopted in general applications (robotics, test benches, sensor data acquisition). This course presents an overview about data acquisition and data analysis methods. In a first part methods used in modern data acquisition systems will be described with a special focus on hardware and electronics. The second part will focus on the data analysis side of a measurement process. The aim is to learn how to get the information hidden inside the data, even in presence of noise, using statistical and computing methods

**Learning Outcomes (further info)**

When successfully accomplished the course the student will have a comprehensive view on how to set up a data acquisition system: the course will give to the student the capabilities to choose the most appropriate hardware depending from the quantity to be measured and the application. Part of the course will be dedicated to learn how to properly design a DAQ system and all the related problematic (sampling rate, noise, amplification, etc.). An overview about Electronics (including microcontrollers, FPGA, amplifiers and analogue electronics, commonly used BUS and sensors) will be discussed. Moreover the course will give an overview of the data analysis process: starting from the raw data, acquired using the instruments presented in the first part of the course, and ending with the physical information. After a brief review of the different types of electronic noise, an overview of the more common methods to extract the signal will be presented. Then useful statistical methods to present and treat the data will be discussed. Finally some real examples of data analysis using a dedicated software framework will be shown.

**Syllabus/Content**

9 hours,

- Data acquisition methods
- Sensors and measurements methods
- Introduction to Electronics 1 (Amplifiers, Filters, S/N ratio, ADC)
- Introduction to Electronics 2 (Real Time systems and Data Acquisition)
- Example and applications

6 hours

- How to extract signal in presence of noise (1h)
- Introduction to Statistical methods: parameters determination and hypothesis testing (1h)
- Data analysis using a scientific software framework based on C/C++ (4h)
    - Calibration of experimental devices and sensors
    - How to separate signal and noise in a given data sample

For whose that are not familiar with C/C++ languages, an extra introductory lesson (2h) will be provided.

## WHO

**Teacher(s):**

Dr. Carlo Canali, carlo.canali@iit.it, +39.010.71781793

Dr. Alessandro Pistone, alessandro.pistone@iit.it, +39.010.71781810

## HOW

**Teaching Methods:**

- Lectures (Slides of the course will be provided)
- Hands-on lectures (Hardware will be provided)
- Practical demonstration coding and computation

**Exam Description:**

Short thesis describing a practical implementation of the contents of the course. The project can be done in groups of maximum 2 students (must be agreed with the teachers). The aim of the project can be proposed by the student and/or by the teachers. The work can include one or both of the following tasks:

- Construction of a real Data Acquisition System
- Implementation of a Data Analysis program/code

**Assessment Methods:**

Thesis will be evaluated by teachers.

## WHERE AND WHEN

**Lesson Location**

Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova. IIT – Room to be defined

**Lesson Schedule**

- 2 March 2020: 11 – 13
- 4 March 2020: 11 – 13
- 9 March 2020: 11 – 13
- 11 March 2020: 11 – 13
- 13 March 2020: 11 – 13
- 16 March 2020: 11 – 13
- 18 March 2020: 10 – 13

**Office hours for student**

Appointments, email.

## CONTACTS

The Teachers' office is in front of the Reception at floor -2 at Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova. Teachers can be contacted by email or by phone to arrange an appointment.

Dr. Carlo Canali, carlo.canali@iit.it, +39.010.2896793

Dr. Alessandro Pistone, alessandro.pistone@iit.it, +39.010.2896810

# Modeling Neuronal Structures

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** ING-INF/06

**Number of hours:** 10 hours

**Credits:** 4 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

- Single neuron models
- Synaptic models
- Large-scale neuronal network models

**Learning Outcomes (further info)**

Goal of the teaching is to provide the theoretical contents for modeling neuronal structures at different scale, from single neuron up to large-scale complex networks. For this reason, the course will be focused on how to model and simulate the electrophysiological activity of neuronal structures.

**Syllabus/Content**

The topics of the course will deal with the computational properties of neuronal structures, from single neurons up to large-scale neuronal networks. Knowledge about the physiological properties of neuronal structures are necessary to understand the entire course.

- Biophysical Models of Neurons
  - Introduction to equivalent membrane circuit and membrane electric properties
  - Passive models and propagation equation
  - Hodgkin and Huxley Model
  - Modeling the neuronal morphology
  - Reduced models: Morris Lecar, Integrate and Fire, Izhikevich model
- Synaptic Models
  - Exponential synapses
  - Destexhe model
  - Spike-timing dependent plasticity (STDP)
- Network Models
  - Firing Rate models
  - Modeling network connectivity
  - Interplay between dynamics and connectivity

## WHO

**Teacher(s):** Paolo Massobrio, 010-3532761, paolo.massobrio@unige.it

## HOW

**Teaching Methods**

Combination of traditional lectures, classroom discussion.

**Exam Description**

Oral exam about the topics of the teaching and/or journal club on papers dealing with the topics of the course.

**Assessment Methods**

Oral exam about the basic and advanced techniques for modeling neuronal structures from single neuron up to large-scale neuronal networks.

## WHERE AND WHEN

**Lesson Location**

Lessons will be done @ Aula Viola at DIBRIS, Via Opera Pia 13, third floor.

**Lesson Schedule**

Lessons will be:
13th, 14th, February 2020 at 10.00-13.00; 14-16.00.

**Office hours for student**

Appointment by e-mail

## CONTACTS

Paolo Massobrio
010-3532761
paolo.massobrio@unige.it
Via Opera Pia 13

# Advanced EEG analyses

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-INF/06**

**Number of hours:** 15 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

Learn how to analyze EEG data, starting from artefact removal from raw data to the group statistical analysis of both sensors' and sources' data.

**Learning Outcomes (further info)**

The present course will introduce the student to the most advanced technique to process the EEG signal and infer over the cortical areas that create it. The course will consists on a first part based on sensors analysis and a second part on distributed sources analysis. Analysis will be performed in both the time and time-frequency domain and will be performed within the Matlab and R environments, using a semi-automatic analysis framework developed in the RBCS department.

**Syllabus/Content**

- Class 1 (3h) EEG signal origin and spatial-temporal-spectral characteristics. Data recording, preprocessing (referencing, filtering and epoching) and artefact removal through independent analysis as implemented in EEGLAB. *Teacher Alberto Inuggi and Claudio Campus*.
- Class 2 (2h) Electrode analysis of ERP. Peak analysis, clustering electrodes and averaging time interval. Subject and group level analysis. Statistical analysis in EEGLAB and R. *Teacher Claudio Campus.*
- Class 3 (2h) Spectral analysis of ER**S**P. Peak analysis, clustering electrodes and averaging time interval. Subject and group level analysis. Statistical analysis in EEGLAB and R. *Teacher Claudio Campus.*
- Class 4 (2h) Introduction to EEG source analysis. Theory, forward model and inverse problem resolution. Differences between dipoles and distributed source analysis. Alternative models. *Teacher Alberto Inuggi.*
- Class 5 (3h) Results post-processing (dimensionality reduction) approaches. Source analysis in Brainstorm. *Teacher Alberto Inuggi.*
- Class 6 (3h). Statistical analysis in SPM. Comparison between EEG, fMRI and TMS tools. Final Examination. *Teacher Alberto Inuggi and Claudio Campus.*

## WHO

**Teacher(s):**

**Alberto Inuggi, +39 010 2897 219, alberto.inuggi@iit.it**

**Claudio Campus, +39 010 2097 208, claudio.campus@iit.it**

## HOW

**Teaching Methods**

Projected slides

**Exam Description**

Students will undergo a 45 minutes written examination consisting in 30 multiple selection questions. 15 questions will regard sensors analysis, 15 the source analysis part.

**Assessment Methods**

In order to obtain the 5 CFU, students are expected to correctly answer to a total of at least 18 questions. Moreover, at least 7 correct answers for each of the two section (sensors and sources) are required.

## WHERE AND WHEN

**Lesson Location**

Lessons will be held in the Center for Human Technologies, Via Enrico Melen 83, Building B,16152 Genova, Italy, IIT Erzelli. The exact room will be later indicated.

**Lesson Schedule**

- 20/01/2020 10:00 – 13:00
- 22/01/2020 10:00 – 12:00
- 24/01/2020 10:00 – 12:00
- 27/01/2020 10:00 – 12:00
- 29/01/2020 10:00 – 13:00
- 31/01/2020 10:00 – 13:00

**Office hours for student**

Students enquires about course content and organization should be sent by e-mail. Personal appointment shall be arranged when necessary.

## CONTACTS

Both teachers work in the Center for Human Technologies, Via Enrico Melen 83, Building B,16152 Genova, Italy, IIT Erzelli. Students should preferably interact with the teachers by e-mail.

# Research Oriented Structural and Functional Neuroimaging

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** **ING-INF/06**

**Number of hours:** 21 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The present course will review the current neuroimaging methodologies used to extract in-vivo information over functional and structural organization of human brain. The aim of the course is teaching students how to read and understand most of the current neuroimaging literature. No practical analysis techniques will be presented. The physical basis of image formation, the specific feature of each neuroimaging method and the technical characteristics of the recording hardware (magnetic scanners and coils) will be also explained.

**Learning Outcomes (further info)**

Medical Imaging was born in 1895 when Roentgen, while experimenting with the peculiar radiation he had just discovered, asked his wife to place the left hand over a photographic plate. Relatively little progress followed until about 1970, when the cost/performance ratio of electronics and computing equipment made digital imaging possible. As a result, almost at the same time, echography, computed tomography and nuclear medicine blossomed and then melted: radiology gave place to medical imaging. Around mid/end of 80's two further steps were done with the discovery of the BOLD effect and the development of the Diffusion MRI technique. With the former the scanner could be programmed to obtain non-invasive maps of functional brain activity, with the latter it became possible to assess the path and the integrity of the white-matter bundles that connect the different brain areas. Neuroimaging was born and rapidly became the most powerful and influencing research approach in neuroscience and a fundamental tool for clinical diagnoses.

The goal of the course is to give a broad perspective of the main neuroimaging technologies available today. Some brief explanations of the physical basis of image formation, of the specific feature of each imaging method and of the technical characteristics of the involved hardware (magnetic scanners) will be given at the beginning of the course. The course will then concentrate on the most used technique in clinical and research context with the clear aim to enable each student to easily read and understand a neuroimaging paper. Special attentions will be given to those non-invasive techniques able to estimate the structural and functional properties of human brain. Among the former, we will introduce the voxel based morphometry (VBM) and the cortical thickness to assess the status of gray matter and two post-processing approaches of the diffusion tensor imaging, the tracto-based spatial statistic (TBSS) and the tractograpy, used to assess the integrity of the white matter fibers bundles. Among the former, we will focus on functional MRI, introducing the independent component analysis to extract the cortical networks present at rest and the methods to assess task-related cortical activation. Finally, a comparison between fMRI and EEG methods to reconstruct cortical activity will be shown, together with a brief introduction to structural and functional connectomics.

**Syllabus/Content**

- Class 1 (3h) Brief introduction to the physical basis of the main MRI images formation (T1, T2, EPI and Diffusion images) and their specific features. *(Teacher Danilo Greco)*
- Class 2 (3h) Introduction to the technical characteristics of the involved hardware 1: magnetic scanner and coils. *(Teacher Danilo Greco)*
- Class 3 (2h) Introduction to the technical characteristics of the involved hardware 2: magnetic scanner and coils. *(Teacher Danilo Greco)*
- Class 4 (2h). Common MRI preprocessing steps. Structural MRI. Evaluating gray matter:
  - density (VBM)

  *(Teacher Alberto Inuggi).*
- Class 5 (2h). Structural MRI. Evaluating gray matter:
  - Thickness

  Pediatric templates, longitudinal coregistration
  *(Teacher Alberto Inuggi).*
- Class 6 (3h) Structural MRI. Evaluating white matter. Diffusion Images analysis,
  - TBSS
  - Tractography

  Functional MRI. Origin of the BOLD signal, fMRI vs EEG comparison. *(Teacher Alberto Inuggi)*
- Class 7 (3h) Functional MRI at rest. Brain functional connectivity (FC).
  - Within networks FC (Melodic analysis).
  - Whole brain FC (seed-based FC)
  - simple (fslnets) and advanced (connectomics) between network FC
    *(Teacher Alberto Inuggi)*

- Class 8 (3h) Functional MRI during a task. Task-based FC (DCM, PPI) and fMRI.
  Epi correction within high field scanners
  Final Examination. *(Teacher Alberto Inuggi*

## WHO

**Teacher(s):**

Alberto Inuggi, Tel. +39 010 8172219 , alberto.inuggi@iit.it

Danilo Greco, danilo.greco@iit.it

## HOW

**Teaching Methods**

Projected slides

**Exam Description**

Students will undergo a 45 minutes written examination consisting in 50 (20 for MRI physics and hardware, 30 for MRI methods) multiple selection questions.

**Assessment Methods**

In order to obtain the 6 CFU, students are expected to correctly answer to a total of at least 30 questions.

## WHERE AND WHEN

**Lesson Location**

Lessons will be held in the IIT Center of Human Technologies. Via Enrico Melen 83, Building B

16152 Genova, Italy. 12th floor

**Lesson Schedule**

- 20 Aprile 09:00 – 12:00
- 22 Aprile 09:00 – 12:00
- 24 Aprile 11:00 – 13:00
- 27 Aprile 11:00 – 13:00
- 29 Aprile 11:00 – 13:00
- 4 Maggio 10:00 – 13:00
- 6 Maggio 10:00 – 13:00

**Office hours for student**

Students can contact the teachers by e-mail whenever needed.

## CONTACTS

Teachers' office is in the 7th floor of IIT Center of Human Technologies. Via Enrico Melen 83, Building B

16152 Genova, Italy. Students can contact them by e-mail whenever needed.

# The 3Rs approach: Replacement, Reduction and Refinement of animal procedures in biomedical research

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-IND/34**

**Number of hours:** 9 hours

**Credits:** 4 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

3Rs methods are becoming an essential element in the whole field of biomedical research, from its most fundamental aspects to its daily applications. Today 3Rs methods represent a multidisciplinary scientific area comprising animal science, basic biology, test development, pharmacology, toxicology, regulations and regulatory practices, as well as ethics and behavioral sciences. The aim of the course is to raise consciousness for the scientific soundness of the 3Rs methodology.

**Learning Outcomes (further info)**

According to European Directive 2011/63/eU1, all personnel working with experimental animals should be educated to be competent to work with animals.

**Syllabus/Content**

The topics cover the 3Rs principle, basic research, toxicological applications, method development and validation, regulatory aspects, case studies and ethical aspects of 3Rs approaches.

- Drivers for the change towards 3Rs
- The 3R concept
- Regulatory testing, validation and applicability domains
- Alternatives to animals in safety and quality testing

## WHO

**Teacher(s):** Laura Pastorino, 0103536547, laura.pastorino@unige.it

## HOW

**Teaching Methods**

Frontal lessons

**Exam Description**

The course will be assessed by an oral exam

**Assessment Methods**

Evaluation of the oral exam

## WHERE AND WHEN

**Lesson Location**

@ UNIGE.

**Lesson Schedule**

20-21 July 2020

**Office hours for student**

Appointments, mail, days reserved for students, etc.

## CONTACTS

laura.pastorino@unige.it

# Nanophotonic devices: from fabrication to applications

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** FIS/07

**Number of hours:** 15 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

This course enables the students to have basic knowledge of: (i) Nanofabrication and cleanroom-based technologies; (ii) Electron and ion beam processing; (iii) Nanophotonic devices for ultrasensitive detection and point of care diagnostics; (iv) Vibrational spectroscopies: Raman scattering and infrared absorption in nanophotonic/biosensor systems.

**Learning Outcomes (further info)**

The fabrication of complex plasmonic nanostructures integrated in innovative device architectures represents a multidisciplinary key activity at the core of most research efforts in nanoscience and technology. In particular, the possibility to manipulate and enhance electromagnetic field at the nanoscale has opened outstanding perspectives in point of care technologies and early disease diagnostics, thus enabling the detection of molecules in highly diluted liquids, and/or the spectral signature collection of single/few molecules concentrated in nanovolumes.

The “hot spot” concept, induced by localized surface plasmon resonances, will be introduced as core idea behind the surface-enhanced infrared absorption (SEIRA) and the surface-enhanced Raman spectroscopy (SERS). Within this context, we will pay attention to the state of the art nanofabrication technologies, e.g. following top-down or bottom-up methods. In details, top-down fabrication refers to approaches such as electron beam lithography or focused ion beam milling where focused electrons or ions are used to carve nanostructures into macroscopically dimensioned materials. Alternatively, in the bottom-up approach, one begins to assemble nanostructures from smaller units. Examples will include colloidal synthesis and unfocused ion beam sputtering.

An introduction (~4 hours) to both Raman and Infrared spectroscopies will be carried out. The topics will include vibrational and rotational spectra, molecular symmetries, instrumentation and sampling methods, environmental dependence of vibrational spectra.

**Syllabus/Content**

- Nanofabrication technologies: top-down and bottom-up approaches for the realization of next-generation devices (~4 hours).
- Nanoplasmonics and Nanophotonics: the physics behind the applications (~2 hours).
- Nanophotonic devices: design and realization of ultrasensitive biosensors (~3 hours).
- Vibrational spectroscopies: Raman scattering and infrared absorption (~4 hours).
- SEIRA and SERS: employing plasmonic devices for the ultrasensitive detection both in the visible and in the infrared range (~2 hours).

## WHO

**Teacher:**

Andrea Toma,
phone number: 010 2896257, email: andrea.toma@iit.it, web page: http://www.iit.it/en/people/andrea-toma.html

## HOW

**Teaching Methods**

The main teaching methods will involve frontal lectures with a dedicated amount of time to teacher-student interactive dialogue (*i.e.* learning-by-discussion method). A tour lab into the IIT clean-room facility will bring the students in direct contact with the main top-down fabrication techniques. Lecture notes and slides will be provided to the students.

**Exam Description**

The final examination consists in a journal club or a brief research project proposal.

**Assessment Methods**

Teacher-students interactive dialog will provide intermediate feedback on the learning progress. A final presentation aimed at bridging the state-of-the art research in nano- bio-photonics with the students' activities (PhD project etc.) will be used as a direct assessment of the learning outcomes. Within this context, the students will be asked to reflect on their learning: a brief research proposal involving both photonics concepts and their own research program will be evaluated during the final examination.

## WHERE AND WHEN

**Lesson Location**

Istituto Italiano di Tecnologia - Via Morego 30, 16163 Genova

**Lesson Schedule**

Lectures will be held on April 3rd, 7th, 17th, 23rd and 29th. Every lesson will be 3 hours long starting at 2pm.

**Office hours for student**

From March to May, office hours are scheduled on Mondays 11am - 12 pm. During the other months office hours are by appointment or email only.

## CONTACTS

Office: room 5/10, Istituto Italiano di Tecnologia via Morego 30. Email (andrea.toma@iit.it) or phone (010 2896257) are the most preferred methods of communication.

# Advanced Optical Fluorescence Microscopy Methods

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: FIS/07**

**Number of hours:** 12

**Credits:** 5 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

This course considers, as starting point, those implementations in advanced optical fluorescence microscopy (AOFM) and fundamental aspects of fluorescence spectroscopy (absorption/ emission spectra, lifetime, energy transfer, intensity fluctuations, etc). The course will consider theoretical and experimental aspects within a critical discussion related to focused applications. The methods of analysis will also be discussed.

**Learning Outcomes (further info)**

The course will address the methods that allow to get 4D(x-y-z-t) information like computational optical sectioning microscopy (COSM), confocal laser scanning microscopy (CLSM), two-photon excitation microscopy (2PEM) and light sheet fluorescence microscopy (LSFM). Variations on the theme will be treated by considering the possibility of getting complementary information by including Second Harmonic Generation, Light Scattering Polarization and Force interaction measurements in AOFM schemes. A possible route to bring such approaches to super resolution methods will be critically discussed.
An overview of quantitative fluorescence-based methods, including Forster Resonance Energy Transfer (FRET), Fluorescence Lifetime Imaging (FLIM), Fluorescence Correlation Spectroscopy (FCS), will be part of the course.

**Syllabus/Content**

- Optical sectioning
- Spatial and Temporal Resolution in image formation
- Laser sources in microscopy
- Quantitative Fluorescence Spectroscopy
- Overview of advanced fluorescence spectroscopy/microscopy methods
- Critical discussion related to the biological, medical or materials science questions

## WHO

**Teacher(s):**

**Paolo Bianchini,** +39 010 2897 613, paolo.bianchini@iit.it

**Alberto Diaspro**, +39 010 2897 609, alberto.diaspro@iit.it

## How

### Teaching Methods

The Course develops in about 12 hours.

### Exam Description

Written test: multiple-choice questions and an open question

### Assessment Methods

Evaluation of the test

## Where and When

### Lesson Location

Istituto Italiano di Tecnologia (CHT- Erzelli), Via E. Melen 83 - Edificio B, 16152 Genoa Italy

### Lesson Schedule

28, 30, of April and 5, 7, 12, 14 of May 2020 from 14.00 to 16.00

### Office hours for student

appointments, email

## Contacts

The offices of both teachers are located at the 5th floor of IIT via Morego 30, 16163 Genova

**Paolo Bianchini,** 010 2897 613, paolo.bianchini@iit.it

**Alberto Diaspro**, 010 2897 609, alberto.diaspro@iit.it

# Fluorescence Super-Resolution Microscopy: Basis, Applications and Perspectives

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** FIS/07

**Number of hours:** 9 hours

**Credits:** 4 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

Is the promise of fluorescent super-resolution microscopy in the 21st-century to reveal the spatial organization of all bio-molecules inside a cell and directly observe their interactions at the highest spatial and temporal levels of detail. This course will explain the basis of fluorescent super-resolution and will introduce all the most important techniques. The course will cover both coordinate-targeted and coordinate-stochastic (also known as single-molecule-localization) approaches. Particular attention will be addressed to stimulated-emission-depletion (STED) microscopy and image scanning microscopy (ISM). The course will discuss about different bio-applications of fluorescence super-resolution microscopy, focusing on the quantitative ability of the techniques to characterize specific bio-molecular properties.

**Learning Outcomes (further info)**

Introduced at the beginning of the 20th-century the fluorescent probes had truly revolutionized optical microscopy. The high sensitivity and specificity of the fluorescent probes in combination with optical microscopy allow understanding life at the molecular level. After one century fluorescent probes become again the major players of a new revolution in optical microscopy. Until the end of the 20th-century, it was widely accepted that due to the diffraction of light the optical microscopes can not visualize details much finer than about half the wavelength of light.  The photo-physical mechanisms of the fluorescent probes, in particular the possibility to drive the probes in distinguishable states, set up the basis for overcoming the limiting role of diffraction. This breakthrough has led to readily applicable and widely accessible fluorescence microscopes with nanometer scale spatial resolution (fluorescence super-resolution microscopy), which can potentially play a relevant role in the groundbreaking progress of life science and neuroscience.

This course will start explaining the reason why diffraction of light imposes a limitation to the spatial resolution of an optical microscope and how this limit can be overcame taking advantages of the photo physical properties of the fluorescent probes. The course will introduce the most important and mature fluorescence super-resolution microscopy techniques. The course will continue focusing on two particular approaches, the STED microscopy and ISM microscopy. The major advantages, limitations and challenges of these two techniques will be deeply discussed and bio-medical applications will be presented. The course will highlight their ability to provide not only spatial information but also correlate them with temporal information (time-resolved spectroscopy), for example the combination of STED microscopy with fluorescence-correlation-spectroscopy will be discussed and ISM with fluorescence lifetime.

Finally, the course will present general perspective about fluorescence super-resolution microscopy.

**Syllabus/Content**

- The resolution and the diffraction limit
- Basis of coordinate-stochastic (single-molecule-localization) and coordinate-targeted approaches
- Advances in STED microscopy
- Advances in ISM microscopy
- Applications of STED microscopy and ISM and their combination with time-resolved spectroscopy

## WHO

**Teacher(s):** Dr. Giuseppe Vicidomini, Molecular Microscopy and Spectroscopy, +39 01071781976, giuseppe.vicidomini@iit.it

## HOW

**Teaching Methods**

This course requires the active participation of all class members through active listening, debate, and discussion. Other instructional methods employed in the course include visiting to the microscopy labs.

**Exam Description**

The examination consists in a brief research project proposal or in an oral presentation.

**Assessment Methods**

Class attendance and regular participation is required for this course. Assessment will be in both written and oral form.

## WHERE AND WHEN

**Lesson Location**

Lessons will be done at the IIT-Center for Human Technology, Via Enrico Melen 83 Edificio B, Genoa. Room will be specify one week before the beginning of the course.

**Lesson Schedule**

The course will be organized in 6 lessons of two hours each. Every lesson will start at 10.00 am and will finish at 12.00 am, except the last one which will finish at 11.00. The lessons are scheduled end of May, begin of June. The calendar will be communicated one month before the beginning of the course.

**Office hours for student**

Dr. Giuseppe Vicidomini receive students on Tuesday from 14.30 to 16.00. For the students it is highly request to fix an appointment by e-mail of phone few days in advance and to wait confirmation from the professor.

## CONTACTS

Dr. Giuseppe Vicidomini

Molecular Microscopy and Spectroscopy

Italian Institute of Technology

Via Enrico Melen, 83, Edificio B, 16152, Genoa, Italy

Office: 12th floor

tel: +39  010 2897607

e-mail: giuseppe.vicidomini@iit.it

# Polymers for sustainability, food packaging and biomedics

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** FIS/07 (fisica applicata) ING-IND/34 (Bioingegneria industriale)

**Number of hours:** 18 hours

**Credits:** 5 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

Basic concepts of polymer preparation coupled with physicochemical characterization techniques, with special focus on polymeric composites. Model applications in different fields (food packaging, circular economy, biomedical).

**Learning Outcomes (further info)**

Polymers are ubiquitous materials due to their broad range of properties, light weight and low cost. In this PhD course, we will show the main reasons that determine the final properties of polymers and how polymer composites can further expand the properties and applications of the base materials. We will describe techniques and methodologies for their fabrication, modification and characterization. Applications in the biomedical field and in packaging will be discussed.

The fabrication methods include standard synthetic and manufacturing (e.g., extrusion, injection molding…) processes.

The characterization ranges from spectroscopies, to investigate the chemical composition, the polymer structure and the molecular arrangement, to the characterization of macroscopic mechanical, thermal and functional properties.

The end-of-life of polymeric material and their environmental sustainability will be discussed.

An overview of the applications of polymers and their composites in different fields, such as food packaging, circular economy and bioengineering, will be presented.

Objectives of this course are the description of the synthetic methodologies and the experimental techniques used for polymer preparation and characterization. The approach is very applied, starting from some samples concerning the fabrication of the most commonly used polymers and the theory for each technique, leading to practical strategies for material testing, result interpretation and device design.

**Syllabus/Content**

**Polymer preparation methods:** synthetic routes for the fabrication of polymers from both a lab and industrial scale point of view. Different manufacturing processes and strategies for polymer synthesis will be shown and discussed.

**Physical-Chemical characterization:** UV/VIS, infrared and Raman spectroscopies and nuclear magnetic resonance, thermal characterization, X-ray diffraction, tests for mechanical properties.

**Approaches to design polymeric materials with improved sustainability:** substitution of raw materials with renewable components and strategies to improve their end-of-life: recyclability, biodegradation, composting. End of life of polymeric material and their recyclability.

**Fabrication methods:** Different fabrication methods, for both lab and industrial scale production, such as spray coating, dip coating, injection molding, extrusion etc will be discussed.

**Sustainable packaging:** we will discuss the development of sustainable materials and the physical properties they must possess for efficient food packaging (wetting properties, oxygen/water vapour permeability etc).

**Naturally-derived polymers:** chemical structures and physico-chemical properties of natural polysaccharides and protein-based materials will be presented, together with their supply and extraction processes. Basic concept of polymeric chain conformation and secondary structures will be reviewed, as closely related to the processing and usage of naturally-derived materials. A panoramic of the applications of natural polymers in various fields (such as medical, pharmaceutical, tissue engineering, biosensors, cosmetics) will be given.

**Biomaterials:** design, development and biomedical application. Overview of the various materials used in the medical field (polymers, metals, ceramics); properties needed for specific applications (tissue regeneration, organoid formation, load bearing in prostheses), biocompatibility and biodegradation concepts, body response to a biomaterial. History of biomaterial design and development. Applications in orthopedics, ophthalmology, cardiovascular systems, dentistry, wound healing.

## WHO

**Teacher(s):**

Giovanni Perotto, giovanni.perotto@iit.it

Evie Papadopoulou, paraskevi.papadopoulou@iit.it

Giulia Suarato, giulia.suarato@iit.it

Phone number: 010 71781 705 (Evie Papadopoulou and Giovanni Perotto)

01071781870 (Giulia Suarato)

## HOW

**Teaching Methods**

Lectures.

**Exam Description**

The examination consists in a written test.

**Assessment Methods**

Formative assessment (feedback with the students by oral questions during lessons).

## WHERE AND WHEN

**Lesson Location**

Lessons will be done @ IIT.

**Lesson Schedule**

Lessons will be in March/April 2020.

**Office hours for student**

Students asking info to the teachers can contact them by email anytime.

## CONTACTS

Teachers' offices are in the 5th floor of the IIT building (via Morego 30, 16163, Genova). Students asking info to the teachers can contact them by email anytime.

# Hybrid microfluidics systems for electronics, photonics, and sensors

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING/INF 01; ING/INF 07**

**Number of hours:** 9 hours

**Credits:** 4 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

This course is intended for PhD students who are interested in getting a better understanding of how the synergistic integration of either optics or electronics with microfluidics enables new applications in several fields such as spectroscopy, microscopy, (bio)sensing, and robotics.

**Learning Outcomes (further info)**

The course illustrates operational principles and functionalities of hybrid microfluidics systems through physics and various examples. No prerequisites are required.

**Syllabus/Content**

The course is divided into 4 sections: 1) Introduction to hybrid systems: history, definitions and fundamental concepts; 2) Microfluidics: the physics of liquids below the microliter scale; 3) Fabrication technologies: materials and micromachining methods; 4) applications: sensors, optics, electronics.

## WHO

**Teacher(s):** Salvatore Surdo, +39 010 28961, salvatore.surdo@iit.it

## HOW

**Teaching Methods**

Frontal lectures with PPT.

**Exam Description**

Short thesis or project proposal dealing with the contents of the course.

**Assessment Methods**

Evaluation of the thesis/proposal

## WHERE AND WHEN

**Lesson Location**

Lesson will take place @ IIT

**Lesson Schedule**

6 th, 13th, 20th and 27th of March

**Office hours for student**

appointments, email

**CONTACTS**

Office: CHT Erzelli, Istituto Italiano di Tecnologia, Via Enrico Melen 83, Building B, 16152 Genova, Italy, 10th floor; E-mail: salvatore.surdo@iit.it

# Principles of Tissue Engineering and Regenerative Medicine

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** ING-INF06

**Number of hours:** 12 hours

**Credits:** 4 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course will provide the students the basic knowledge about:

- cell biology

- techniques to fabricate and/or characterise biomaterials for tissue engineering

- bioreactors for tissue engineering

- in vivo tests and current clinical applications

**Learning Outcomes (further info)**

Tissue Engineering is a multidisciplinary field involving biology, medicine, material science and bioengineering aimed to improve the health and quality of life for millions of people worldwide by restoring, maintaining, or enhancing tissue and organ function. Tissue engineering research includes the following areas: (i) Cell biology: including enabling methodologies for the proliferation and differentiation of cells, acquiring the appropriate source of cells such as autologous cells, allogeneic cells, xenogeneic cells, stem cells, genetically engineered cells, and immunological manipulation. (ii) Biomaterials: including novel biomaterials designed to direct the organization, growth, and differentiation of cells in the process of forming functional tissue by providing both chemical and physical (macro-micro-nano scale) cues. Biomechanical Aspects of Design: including properties of native tissues, identification of minimum properties required of engineered tissues, mechanical signals regulating engineered tissues, and efficacy and safety of engineered tissues. (iii) Biomolecules: including growth factors, differentiation factors, angiogenic factors, their synthesis and their release. (iv) Engineering Design Aspects: including 3D tissue growth, modeling of scaffold internal architecture, bioreactors to offer specific stimulation to living tissues, design of organ on chip technologies.

**Syllabus/Content**

- Cell-Based Therapies for TE: methodologies for isolation, differentiation, selection of adult progenitors/stem cells.
- Biomaterials for TE: design of intelligent materials; study or the proper macro-micro-nano-structures, chemical compositions, biomechanical properties; cell-biomaterials interfaces, bioactivation of surfaces.
- Bioreactor systems for TE: perfusing bioreactor systems, biomechanical stimulating bioreactors, fluido-dynamic stimulating bioreactors.
- Pre-clinical/Clinical models: in vivo case studies, implant of cell-biomaterials constructs, animal models.

## WHO

**Teacher(s):** Alessandra Marrella

phone number: 010 6475 215; email: alessandra.marrella@ieiit.cnr.it

## HOW

**Teaching Methods**

Combination of traditional lectures and classroom discussion.

**Exam Description**

The examination consists in a journal club or a brief research project proposal.

**Assessment Methods**

A final presentation covering the topics of the course will be used as a direct assessment of the learning outcomes.

## WHERE AND WHEN

**Lesson Location**

(CNR) - Via De Marini, 6, 16° floor

**Lesson Schedule**

9th March 2020, 9-11

13th March 2020, 9-11

16th March 2020, 9-11

23th March 2020, 9-11

30th March 2020, 9-11

6th April 2020, 9-11

**Office hours for student**

Mail

## CONTACTS

Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni (IEIIT), Consiglio Nazionale delle Ricerche (CNR) - Via De Marini, 6, 16° floor. Email (alessandra.marrella@ieiit.cnr.it) is the most preferred method of communication.

# Psychophysics Methods

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:** M-PSI/01

**Number of hours:** 12

**Credits:** 2 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The students will learn the basics of psychophysics, starting from the learning of the main methods of evaluation of the perceptive thresholds to the planning of a full psychophysical experiment.

**Learning Outcomes (further info)**

Psychophysics is that part of psychology that investigates the relationship between inputs come from the environment and sensations/perceptions they produce using a scientific approach. It provides a corpus of well-established methods to study and formulate models of perception.
The course will start with a review of the history of psychophysics and of the main results obtained in this field. Then, the course will present some psychophysical concepts (e.g., the concepts of sensory threshold and psychological scale) and describe classic and modern psychophysical methods to measure them.
The students will have the opportunity to make simple psychophysical experiments in class to test their understanding of the methods.

**Syllabus/Content**

Class 1 (3 hours): History of psychophysics and concept of threshold
Class 2 (2 hours): Methods of threshold measurement
Class 3 (2 hours): Measurement of sensory attributed and discrimination scales
Class 4 (3 hours): Laboratory
Class 5 (2 hours): Final Exam.

## WHO

**Teacher(s):**

Monica Gori – Istituto Italiano di Tecnologia – +39 0108172217, monica.gori@iit.it

Alessia Tonelli – Istituto Italiano di Tecnologia – +39 0108172232, alessia.tonelli@iit.it / tonelli.alessia@gmail.com

## HOW

**Teaching Methods:**

Frontal lessons and laboratories

**Exam Description:**

The exam will consist of a multiple-choice questionnaire, which must be completed in one hour.

**Assessment Methods:**

In order to obtain the 4 CFU, students have to answer correctly at least at the 60% of the questions.

## Where and When

**Lesson Location**

The lessons will be held at IIT – Erzelli. The name of the room depends on availability and will be communicated in advance

**Lesson Schedule**

The course will be held in mid September 2020. Each class will last 2/3 hrs.

**Office hours for student**

Students enquires about course content and organization should be sent by e-mail. Personal appointment shall be arranged when necessary.

## Contacts

Students can contact the teacher by email:

Monica Gori – monica.gori@iit.it

Alessia Tonelli – alessia.tonelli@iit.it or tonelli.alessia@gmail.com

# Cognitive Robotics for Human-Robot Interaction

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:**

**Number of hours:** 18 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The participants will learn the key aspects regulating the interaction between human and robots, and will have an overview of good features and limitations of currently available platforms for HRI. Students will learn how to conduct an HRI study and which metrics are appropriate to characterize the interaction.
Participants will be provided with an overview of some computer vision and machine learning techniques useful to make robots able to understand the nonverbal behaviors of the human partner (e.g. facial expressions and body movements). A broad survey across cognitive models of perception and action will give to the participants the opportunity to successfully design new behaviors for interacting robots.
Moreover, participants will have the chance to program the humanoid robot iCub.

**Learning Outcomes (further info)**

In this course the students will learn the different roles a robot could play in the context of human-robot interaction, as for instance the tutor, the collaborator, the companion or the tool of investigation, and the corresponding different models of interaction. The course is aimed at providing a clear understanding of what are the good features and limitations of the robotic platforms currently available.
The students will be presented with computer vision and machine learning techniques useful to endow the robot with the capability of understanding human behaviors (for instance motion and facial expressions) that are relevant in natural human-robot interaction.
The participants will learn how to design and implement robot perceptual, motor abilities structured in a cognitive framework for natural human-robot interaction, and will have the chance to learn how to program the humanoid robot iCub.

**Syllabus/Content**

- Taxonomy and Open Challenges for HRI
- The importance of Robot Shape, Motion and Cognition
- Metrics and Experimental Design
- Computer Vision and Machine Learning for HRI
- Models of Robot Perception and Action in HRI
- Software Development of perception and action models in HRI

## WHO

**Teacher(s):**

Francesco Rea, +393383468679, francesco.rea@iit.it

Alessandra Sciutti, +393297263118, alessandra.sciutti@iit.it

Alessia Vignolo, +393407875890, alessia.vignolo@iit.it

## HOW

**Teaching Methods:**

The course will be structured as a series of frontal lessons progressing from an introduction to the basis of HRI to the specific description of the principal methodologies supporting the analysis and the realization of effective HRI. It will be proposed to the students to proactively participate as groups in short exercise and practical sessions or in group discussions addressing the topics of the lectures.

**Exam Description:**

At the end of the course the students will be involved in designing either an HRI experiment or practical solutions for specific HRI case studies. The participants will work together in small groups of 3/4 persons and will have to leverage on the methods learned during the previous lessons in order to provide an effective solution to the proposed HRI problem.

**Assessment Methods:**

The teachers will assess the effectiveness and appropriateness of the HRI solution or HRI experiment designed during the exam. The assessment will take in consideration how the students selected and implemented the techniques learnt during the course.

## WHERE AND WHEN

**Lesson Location**

The lessons will take place at the Italian Institute of Technology, Center for Human Technologies (room to be defined).
The part of robot programming will require the use of the robot iCub and will be held in the laboratory of Robotics, Brain and Cognitive Sciences Unit.

**Lesson Schedule**

Weeks: from 25th to 29th May, from 1st to 11th June .

**Office hours for student**

Office time is flexible and the student can agree with the teacher an appointment by sending an email either to francesco.rea@iit.it, alessandra.sciutti@iit.it or alessia.vignolo@iit.it

## CONTACTS

The offices are located at

Robotics Brain and Cognitive Sciences Unit (RBCS) and
COgNiTive Architecture for Collaborative Technologies Unit (CONTACT)

Istituto Italiano di Tecnologia
Center for Human Technologies
Via Enrico Melen 83, Building B
16152 Genova, Italy

# Robotic technologies for sensorimotor rehabilitation

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector: ING-INF/06**

**Number of hours:** 16 hours

**Credits:** 6 CFUs

## AIMS AND CONTENT

**Learning Outcomes (short)**

The course will present the different concepts underlying robotic rehabilitation. It will discuss the limitation of conventional physical therapy and the potential of robotics in the field of rehabilitation. Emphasis will be given both in technological and neuroscientific aspects related to the recovery of impaired patients.

**Learning Outcomes (further info)**

Rehabilitation robotics is the application of robots to overcome disabilities and improve quality of life after brain injuries. In contrast with other areas in robotics, this course considers not only engineering design and development, but also the human factors that make some innovative technologies successful.

The first part of the course will deal with the clinical and neuroscientific aspects related to the rehabilitation. The second part will analyze the technological characteristics needed to design robots able to interact with humans.

Ultimately, the last part will present examples on how the two parts can be combined in order to optimally design robots and the related rehabilitation protocols to effectively improve subjects' recovery process.

**Syllabus/Content**

- The concept of robotic rehabilitation
- Conventional rehabilitation techniques
- Neural plasticity and sensorimotor functions
- Robots for rehabilitation: manipulators, exoskeletons
- Possible control strategies: assistive, passive, active
- Case studies and future trends
- Laboratory

## WHO

**Teachers:**

Jacopo Zenzeri, 3408311387, jacopo.zenzeri@iit.it

Pietro Morasso, 3281003224, pietro.morasso@iit.it

## HOW

**Teaching Methods**

For the theory lessons, slide presentation and discussion of a reading list

For the lab activity direct involvement in experiment planning and data processing

No Prerequisites

Reading List: Specific readings will be assigned for each class.

**Exam Description**

There will be a final examination decided by the instructors and communicated to the students at the beginning of the course, after contacting the students and evaluating their background.

**Assessment Methods**

The assessment method will be decided by the instructors and communicated to the students at the beginning of the course.

## WHERE AND WHEN

**Venue**

Istituto Italiano di Tecnologia, Campus Erzelli (Via Melen 83, Bldg B, 16152 Genova)

**Course dates & Schedule**

Campus Erzelli: 12 hours (theory), 9-10-11 March 2020, time 11-13 and 14-16, ($10^{th}$ floor - room to be decided 1 month in advance)

Campus Erzelli: 4 hours (lab); 13 March 2020, time 14-18, MLARR lab ($7^{th}$ floor)

**Office hours for student**

Appointments by email request

## CONTACTS

Jacopo Zenzeri, IIT Campus Erzelli, 7th floor, 3408311387, jacopo.zenzeri@iit.it

Pietro Morasso, IIT Campus Erzelli, 7th floor, 3281003224, pietro.morasso@iit.it

# Robotic Virtual Prototyping Design

**Unit code**: (filled by Unige administrative office)

**Scientific Disciplinary Sector:**

**Number of hours:** 18 hours

**Credits:** 6 CFU

## AIMS AND CONTENT

**Learning Outcomes (short)**

The aim of the Robotic Virtual Prototyping Design course is to give the basic knowledge about the Finite Element Analysis (FEA) and Multi-Body Simulations (MBS) applied to the robotics. These computational techniques predict the behavior of physical systems: joined together permit to study the dynamics taking in account the body flexibility, the control and optimization. It will be introduced mainly applied to the mechanical field, in particular to the robotic anthropomorphic arm. The student gets 5 credits if he/she attends the entire course and accomplishes the final project.

**Learning Outcomes (further info)**

Virtual Prototyping Design is the basic part of the Computer Aided Engineering (CAE) that in the last decades involved more and more the R&D of the industries and the Research Centres. The reason is that the physical models need more time and energies for being improved than virtual ones. Moreover, running numerous simulations, these models permit to be optimized depending on several parameters.

Thus the course will give an overview on the virtual prototyping design building the models with the main software (MSC.Nastran, Ansys/Workbench and MSC.Adams). In the second part of the course, Multibody and Finite Element Analysis will be integrated in order to take the best advantage from the virtual prototyping technique and applied to some mechanisms and robot arms. Then the control (Matlab/Simulink) and the optimization (ModeFRONTIER) will be applied to the simulations.

Even if the training solutions concern the mechanical and robotic problems, it is designed to provide to attendants with both the comprehensive and subject-specific knowledge; the students need to effectively apply software tools to solve general problems: static, dynamic, linear, non-linear and motion or multi-physics analysis. So the aim of the course is not only knowing the performances of the software used to build the basic models, but it is also to be able to improve their skill by themselves.

**Syllabus/Content**

- class 1 (C1)
  - Overview on Virtual Prototyping: Finite Element Analysis (FEA) and Multibody Simulation (MBS)
  - FEA (Ansys/Workbanch)
- class 2 (C2)
  - Anthropomorphic Arm Modelling (FEA+MBS: Ansys/Workbanch)
- class 3 (C3)
  - MBS + FEA (MSC.ADAMS + MSC.Nastran)
- class 4 (C4)
  - MBS + FEA + Embedded Control (MSC.ADAMS + MSC.Nastran)
- class 5 (C5)
  - Anthropomorphic Arm Modelling: MBS+ FEM + Co-Simulation Control (MSC.ADAMS + MSC.NASTRAN + MatLab)
- class 6 (C6)

- Anthropomorphic Arm Modelling: MBS + FEM + Control + Optimisation (MSC.ADAMS + MSC.NASTRAN + MatLab + ModeFRONTIER)
- class 7 (C7) Project Assignment (optional)
  - Final Project Assignment

## WHO

**Teacher(s):**

| | | |
|---|---|---|
| *Ferdinando Cannella* | *01071781562* | *ferdinando.cannella@iit.it* |
| *Mariapaola D'Imperio* | *01071781562* | *mariapaola.dimperio@iit.it* |

## HOW

**Teaching Methods**

Methods

The course will be based on 5 traditional teacher-led mixed to hand-on lectures
Slides of the course will be provided before each lectures
(Optional) Final project for the exam will be prepared with the teachers during the 6th lectures

Prerequisites

Basic knowledge: classical physics and programming.

Installed Software: MSC ADAMS, ANSYS/Workbench, MatLab/Simulink and ModeFRONTIER should be already installed before the lectures (the software will be provided by the teachers for those who have not got them).

Reading List

- Klaus-Jurgen Bathe, Finite Element Procedures, Prentice-Hall of India, 2009
- Robert D. Cook, David S. Malkus, Michael E. Plecha & Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley & Sons, 2001 (ISBN: 0 471 35605 0)
- Rajiv Rampalli, Gabriele Ferrarotti & Michael Hoffmann, Why Do Multi-Body System Simulation?, NAFEMS Limited, 2011
- R.J.Del Vecchio, Design of Experiments, Hanser Understanding Books, 19971.

Remarks

Weekly homework will be assigned at the end of each lecture with an estimated average workload of 1 hours per week. Nevertheless the Project Assignment has an estimated average workload of 1-2 days.

- the minimum attendance is 4 out 6 classrooms (the Project Assignment is not mandatory);
- the Project Assignment should be pass according to the policy.

**Exam Description**

- the minimum mark to pass the Project Assignment is 75%;
- the Project Assignment is due 4 weeks after they are assigned and should be done in a neat and orderly fashion on PowerPoint presentation following the template (provided with the Project Theme). Late submission will not be accepted;
- the project can be:
  1) standard project (proposed by teachers)
  2) project related to the student PhD project (proposed by the student)
  3) quick paper publication on a topic to be decided (teachers and student together)

**Assessment Methods**

The Students should provide the:

- kinematics, dynamics of the project mechanism with rigid and flexible component(s)
- numerical models, drawings and charts of comparison of these two conditions
- PowerPoint presentation (according to the provide template)

## WHERE AND WHEN

### Lesson Location

Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova.
The Meeting room will be communicate to the attendees two weeks in advance the course.

### Lesson Schedule

Wednesday 01st July 2020 14:30-17:30
Friday 03rd July 2020 14:30-17:30
Wednesday 08th July 2020 14:30-17:30
Friday 11th July 2020 14:30-17:30
Wednesday 15st July 2020 14:30-17:30
Friday 17th July 2020 14:30-17:30
Wednesday 22nd July 2020 14:30-17:30 (optional)

### Office hours for student

The teachers will be available (on the office or on skype) every Wednesday morning from 11:00 to 14:30 from 1st July to the 31st July 2020

## CONTACTS

The Teachers' office is in Unità di Robotica Industriale at -2 floor at Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova.

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