PhD Courses offered (2021-2022)

Sommario

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 (24 Credits)

Theatrical techniques for scientific presentation[1]	Sgorbissa A.	5
Ethics and Bioethics in Bioengineering and Robotics[1]	Battistuzzi L.	5
Paper Writing[1]	Marchese M.	5
Grant writing[2]	Leone C.	5
An Introduction to Open Science and Research Data Management	Pasquale V./Pastorini A.M.	4

Suggested Courses

Legal Issues in Bioengineering and Robotics	Di Gregorio V.	3

Basic Courses

Introduction to Computer Programming for Researchers[3]	Goccia M.	2
Data acquisition and data analysis methods	Canali C./Pistone A.	2

Foundation Courses

Programming

C++ programming techniques	Solari F./Chessa M.	6

[1] Recommended for 1st year students
[2] Recommended for 2nd and 3rd year students
[3] For non-engineers

Robot programming with ROS	Recchiuto C.	5
Modern C++	Accame M.	5
Mechanical Drawing Fundamentals (BASIC)	Torazza D.	2
Computer aided design	Torazza D.	5

An introduction to spatial (6D) vectors and their use in robot dynamics	Featherstone R.	4
Computational Robot Dynamics	Featherstone R.	5
Perceptual Systems	Gori M./Tonelli A.	4
Electronics and Circuits (level 1)	Sartore M.	3
Electronics and Circuits (level 2)	Sartore M.	3
Electronics and Circuits (level 3)	Sartore M.	3
Electronics and Circuits (level 4)	Sartore M.	3
Motion control drivers (level 1)	Sartore M.	3
Motion control drivers (level 2)	Sartore M.	3
Motion control drivers (level 3)	Sartore M.	3
Motion control drivers (level 4)	Sartore M.	3

Speciality Courses

Advanced EEG analyses	Inuggi A./Campus C.	5
Research oriented structural and functional neuroimaging	Inuggi A./Greco D.	6
The 3Rs approach: Replacement, Reduction and Refinement of animal procedures in biomedical research	Pastorino L. Di Lisa D.	4
An introduction to body-machine interface	Pierella C.	4

Advanced Fluorescence Microscopy Methods	Bianchini P. Vicidomini G.	4
Polymers for sustainability, food packaging and biomedics	Perotto G. /Papadopoulou E. /Suarato G.	6
Microfluidics and nanofluidics: theory and recent applications	Surdo S./ Perego E.	4

Cognitive Robotics for Human-Robot Interaction	Rea F./Tanevska A./Sciutti A./Zonca J.	8
Introduction to physical Human-Robot Interaction	Zenzeri J.	4
An introduction to modern neurophysiology: bridging experimental tools and computational strategies to unlock the brain	Maffulli R. / Panniello M.	4
Introduction to space exploration	Malerba F.	5

Robotic technologies for sensorimotor rehabilitation	Morasso P./Zenzeri J.	5
Robotic Virtual Prototyping Design	Cannella F. /D'Imperio M./ Abidi H.	6

Mechatronics and AI	Cannella F. / Abidi H.	6
Theory and Practice of Learning from Data	Oneto L.	5

Ethics and Bioethics in Bioengineering and Robotics

Unit code: (filled by Unige administrative office)

Scientific Disciplinary Sector: MED02/MED43/M-FIL03

Number of hours: 15

Credits: 5

AIMS AND CONTENT

Learning Outcomes (short)

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

- explain some of the key ethical and bioethical 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 may 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
- Ethical issues in human-robot interaction
- Value Sensitive Design in bioengineering

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 split into groups and each group 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 case and discuss it during class time. Contributions to class discussion will be considered a part of the assessment.

WHERE AND WHEN

Lesson Location

UNIGE.

Lesson Schedule

Monday Jan 10 (10.30 – 12.30)

Thursday Jan 13 (10.30 – 12.30)

Monday Jan 17 (10.30 – 12.30)

Thursday Jan 20 (10.30 – 12.30)

Monday Jan 24 (10.30 – 12.30)

Thursday Jan 27 (10.30 – 13.00)

Monday Jan 31 (10.30 – 13.00)

Office hours for student

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

CONTACTS

Students should contact me by email.

Grant Writing

Scientific Disciplinary Sector: ING-INF/05

Number of hours: 12 hours

Credits: 5 CFU

AIMS AND CONTENT

Learning Outcomes (short)

The course will present and discuss guidelines on how to design a research grant proposal and on the coordination of a research grant, with a special focus on European Horizon Europe Framework Programme. The students will be invited to participate to concrete exercise and the drafting of real and possible project ideas. A part of the lessons is dedicated to participatory activities.

Learning Outcomes (further info)

A particular focus will be on project proposals to be developed by PhD students and Early Stage Researchers. Use cases of successful projects coordinated by the teacher will be studied and analysed. A short simulation of the development process of a draft research proposal will conclude the course.

Syllabus/Content

European research grants, EU Horizon Europe, Project Drafting.

WHO

Teacher(s): Cinzia Leone, email: cinzia.leone@unige.it

HOW

Teaching Methods

Direct instruction (slides and course material) followed by a flipped classroom final short session.

Exam Description

Written exam (test and open questions) followed by a discussion of an example of case study.

Assessment Methods

Exam (test and oral discussion)

WHERE AND WHEN

Lesson Location

@UNIGE: TBD

Lesson Schedule

October 3rd 9:00-13:30

October 5th 9:00-13:30

October 7th 9:00-13:30

Office hours for student

Emails and appointments on request.

CONTACTS

The teacher is available by email (cinzia.leone@unige.it).

Theatrical techniques for scientific presentation

Scientific Disciplinary Sector: ING-INF/05

Number of hours: 12

Credits: 5

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 or VIDEOCONFERENCE

Lesson Schedule

- April 26th 10:00-13:00
- May 2th 10:00-13:00
- May 11th 10:00-13:00
- May 20th 10:00-13:00

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.

Open Science and Research Data Management (OS&RDM)

Scientific Disciplinary Sector: ING/06

Number of hours: 10

Credits:4

AIMS AND CONTENT

Learning Outcomes

This training course for PhD Students aims to introduce early-career researchers to scholarly communication and to the principles of Open Science (Open Access to Publications, Open Data, Open Licenses) and Research Data Management. At the end of the course students will have a better understanding of the available research e-infrastructures, tools, and services for Open Access Publication, Research Data Management and FAIR Data. Students will also learn the importance of open science in research, especially to improve science reproducibility and increase research integrity. They will learn how to make research data FAIR, as required by many funders, including the European Commission, and how to draft a data management plan. Finally, they will have the chance to practice on common tools for Research Data Management, like DMPOnline and Zenodo.

Contents

Module 1:

Setting the context: why open science? (V. Pasquale, A. M. Pastorini)

Open science: a definition; benefits of open science: for researchers and for the scientific system and society as a whole.

Short intro to the contents of the course.

Scholarly communication (A. M. Pastorini)

What is scholarly communication; the publication cycle and type of publications; peer-review process; bibliometrics (impact factor, h-index, other indicators, bibliometrics limits); citation databases; avoid plagiarism; literature search engines and reference managers.

The management of rights in scholarly communication (A. M. Pastorini)

Intellectual property: trademarks and patents; author's rights and copyright (Italian and European contexts); fair use vs exceptions and limitations to rights; editorial policies: contract and license; open access as an economic model; open licenses for sharing contents and data

Module 2:

Open access in scholarly communication (A. M. Pastorini)

Overview on open access; open digital repositories and institutional archives; open access journals and bibliometrics; the different business models of open access; cOAlitionS and PlanS; OA policies and regulations (with specific reference to Unige and IIT context).

Author's rights and PhD Thesis (A. M. Pastorini)

Author's rights and PhD Thesis; regulation about PhD Thesis; the submissions of PhD Thesis in the institutional repository (IRIS UniGe); information and support: the OS UniGe website www.openscience.unige.it; open science & RDM support in IIT (*V. Pasquale*).

Module 3

What is Research Data Management? (V. Pasquale)

Research data management: a definition; Research data lifecycle: from data management planning to sharing.

The Research Data Lifecycle: Plan & fund (V. Pasquale)

Funder requirements; data management planning; data ownership; basic notions of data privacy & ethics; support for DMP in IIT.

Hands-on activity: using online tools for data management planning (V. Pasquale)

Students will be asked to draft a data management plan of their PhD project by using online tools (DMPOnline, Data Stewardship Wizard).

Module 4

The Research Data Lifecycle: Work with data (V. Pasquale)

Secure storage & backup; tips & tricks: file formats, data organisation, filenaming conventions, version control and house-keeping; data documentation: electronic lab notebooks.

The Research Data Lifecycle: Preserve & share (V. Pasquale)

FAIR data: how to make your data FAIR; data and metadata standards; digital preservation: repositories, open data licenses, persistent identifiers, how to make your research outputs (data, models, code) citable.

Hands-on activity: share a dataset in a trusted repository (V. Pasquale)

Students will be asked to create a dataset and share it by using a trusted repository (e.g., Zenodo, Dataverse, figshare, etc.)

WHO

Teacher(s): Anna Maria Pastorini, SBA UNIGE, annamp@unige.it; Valentina Pasquale, IIT, valentina.pasquale@iit.it.

HOW

Teaching Methods

Face-to-face and online lectures, hands-on activities.

Exam Description

To be recognized credits (CFU), students will have to take an exam. The exam may consist in a combination of multiple-choice tests and/or practical activities, such as the elaboration of a sample data management plan and/or sharing a research dataset.

Assessment Methods

Students will be evaluated on the basis of the multiple-choice tests, and/or on the execution of practical activities.

WHERE AND WHEN

Lesson Location

Face-to-face lectures will be organized either at UNIGE or IIT (TBD). Microsoft Teams will be used for online lectures. AulaWeb will be used to communicate with students.

Lesson Schedule

Period: 1, 3, 14, 16, 17 February (10-12).

Office hours for student

Students can ask questions sending emails to the teachers. Office hours: 8.30-17.30.

CONTACTS

Anna Maria Pastorini, Servizio Sistema Bibliotecario di Ateneo, Ufficio Biblioteca Digitale e Open Access, Università di Genova

Email: annamp@unige.it

Valentina Pasquale, Research Data Management specialist, Via Morego 30, 16163, Genova (1st floor)

Email: valentina.pasquale@iit.it

Data Acquisition and Data Analysis Methods

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 about measurements and uncertainty, an overview of random variables, outcomes of experiments and propagation of uncertainty will be presented. Then useful statistical methods to present and treat the data will be discussed. Finally some real examples of data analysis using MATLAB® 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

- Dealing with uncertainties (1h)
- Introduction to Statistical methods (1h)
- Data analysis using MATLAB® (4h)
    - Curve fitting and parameters identification
    - Periodicity analysis and pre-processing tools

WHO

Teacher(s):

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

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

HOW

Teaching Methods:

- Lectures (slides of the course will be provided)
- Hands-on lectures (hardware will be provided)
- Practical demonstration coding and computation (students will need access to MATLAB®)

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

- 1 March 2022: 10 – 12

- 8 March 2022: 10 – 12
- 15 March 2022: 10 – 12
- 22 March 2022: 10 – 12
- 29 March 2022: 10 – 12
- 31 March 2022: 10 – 12
- 5 April 2022: 10 – 13

Office hours for student

Appointments, email.

CONTACTS

The Teachers' office is at 4th floor 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

Introduction to Computer Programming for Researchers

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):

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

or

Online (depending on the circumstances)

Lesson Schedule

Wednesday 19 January 2022, 9:00-12:00

Friday 21 January 2022, 9:00-12:00

Tuesday 25 January 2022, 9:00-12:00

Thursday 27 January 2022, 9:00-12:00

Friday 28 January 2022, 9:00-12:00

Office hours for student

Students can send email.

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

Modern C++

Scientific Disciplinary Sector: ING-INF/05 / ING-INF/06

Number of hours: 15

Credits: 5

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.

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 (Center for Robotics and Intelligent Systems), Via San Quirico 19D, 16163 Genova, Italy

Or remotely through Teams platform in case of impossibility.

Lesson Schedule

1. Introduction: on **4 October 2022**, 1400-1630
2. The basics 1: on **6 October 2022**, 1400-1630
3. The basics 2: on **11 October 2022**, 1400-1630
4. Advanced topics 1: on **13 October 2022**, 1400-1630
5. Advanced topics 2: on **18 October 2022**, 1400-1630
6. Advanced topics 3: on **20 October 2022**, 1400-1630

The dates of the two tests related to modules 1, 2, 3 and to modules 4, 5, 6 will take about 1 hour each. The dates will be agreed at the beginning of the course.

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 “[MODERN-C++]”,
- phone
- Teams platform after arranged appointment.
- Face to face if sanitary conditions allow.

Computational Robot Dynamics

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 and forward 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 building a dynamic model of a robot through to what is happening inside the dynamics simulator, plus detailed descriptions of the main dynamics algorithms and how to implement them efficiently.

Syllabus/Content

- dynamic models of robots
- inverse dynamics, and the idea of a recursive algorithm
- efficient implementation of spatial vector arithmetic
- forward dynamics
- how a dynamics simulator works

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 Morego (room not allocated yet).

Lesson Schedule

Four 3-hour sessions in the afternoon (14:30-17:30) from Monday 23rd to Thursday 26th May 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 on the top floor of the new IIT building on via San Quirico (CRIS). Students can contact him via email: roy.featherstone@iit.it

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

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

- vectors and vector fields
- 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 Morego (room not allocated yet).

Lesson Schedule

Four 2.5-hour sessions in the afternoon (15:00-17:30) on Monday 16th, Tuesday 17th, Wednesday 18th and Thursday 19th May.

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 on the top floor of the new IIT building on via San Quirico (CRIS). Students can contact him via email: roy.featherstone@iit.it

Perceptual systems

Scientific Disciplinary Sector: M-PSI/01

Number of hours: 12

Credits: 4

AIMS AND CONTENT

Learning Outcomes (short)

Students will learn how the functioning of the main sensory systems, i.e. vision, audition, touch, small and taste. 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. How the brain process and transform sensory signals into perceptual outputs is one of the main questions in the field of experimental psychology. The goal of the course is to present the perceptual 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 in a 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 (3 hours): Auditory and tactile systems.
Class 3 (3 hours): Multisensory integration and development of sensory systems.
Class 4 (2 hours): Olfactory and gustatory systems and cross-modal interaction.
Class 4 (1 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

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 65% of the questions.

WHERE AND WHEN

Lesson Location

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

Lesson Schedule

The course will be held in September from 19th to 22nd 2022. Each class will last 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

Robot programming with ROS

Scientific Disciplinary Sector: ING-INF/05

Number of hours: 15 hours

Credits: 5 CFU

AIMS AND CONTENT

Learning Outcomes (short)

- Learning and understanding the ROS communication architecture.
- Understanding the ROS2 basic concepts and how to integrate ROS2 with ROS1 systems

Learning Outcomes (further info)

ROS is a robotic middleware that 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. Please notice that the course will not describe in detail the ROS framework, but it will give some general operative instructions (classes I - II), and it will then deal with some specific aspects (classes III-V): in particular, 3D simulations and the integration of ROS-based architecture with ROS2 systems. For this reason, the course may be useful both for students that are already proficient with ROS, which may review some general aspects and possibly learn some new concepts, and for students who have never used ROS, which will receive some insights about ROS (that may be possibly individually deepened) and some of its features.

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, a Docker image with ROS and ROS2 already installed will be given to students.

Syllabus/Content

- Class I (C1) (3 hours) - Introduction to ROS Topics, Services and Nodes. Class examples -
- Class II (C2) (3 hours) – Custom messages and services. ROS Actions. Class examples.
- Class II (C3) (3 hours) – Robot modelling and 3D simulations. Class examples and Assignment I.
- Class IV (C3) (3hours) – ROS2 Topics, Services and Nodes
- Class V (C5) (3 hours) – Components in ROS2 and ROS1/ROS2 bridge. Class examples and Assignment II.

WHO

Teacher(s): Prof. 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 3nd and of the 5th lecture.

Exam Description. The assignments will consist of 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 of 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

To be defined

Lesson Schedule

September 5th 2022, 10:00-13:00

September 6th 2022 , 10:00-13:00

September 7th 2022 , 10:00-13:00

September 8th 2022 , 10:00-13:00

September 9th 2022, 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, Assistant Professor, Laboratorium (DIBRIS, E building 2nd floor)

Phone: +390103532801

Mail: carmine.recchiuto@dibris.unige.it

Electronics and Circuits

Scientific Disciplinary Sector: ING-INF/01

Number of hours: 48 (divided in 4 Levels of 12 hours each)

Credits: 3 per Level

AIMS AND CONTENTS

Learning Outcomes (short)

Level 1: analog and digital electronics Level 2: mixed signals and data conversion Level 3: advanced design techniques

Level 4: CAD design of Printed Circuit Boards (PCBs)

Learning Outcomes (further info)

Level 1: learning basic Operational Amplifier circuit design and practices; learning digital electronics basics.

Level 2: understanding Analog-to-Digital and Digital-to-Analog conversion and being able to write the specifications of an analog system for signal conditioning and of a mixed-signal system (signal conditioning, data acquisition, filtering) to provide to a thirdy-part designer or to select an off-the-shelf solution available on the market

Level 3: more electronic components; schematic circuit design of "standard modules" to be used as building-blocks in more complex or custom systems, more advanced technical issues (e.g. circuit layout dos and don'ts), circuit design best practices

Level 4: learning a CAD tool for the design of circuit schematics and of the related customized Printed Circuit Boards.

Syllabus/Content

Level 1: students will learn the Operational Amplifier and will be able to go through a typical Datasheet, understanding the various features and characteristic curves. In this module they will practice with basic circuits while learning how to optimize the design in terms of requested features (e.g. noise, stability, etc.).

In the second part students will go through the basics of digital design, confining the activities on typical digital building blocks useful for the following

Level 2: students will mix the acquired concepts into the A/D and D/A technologies, learning how to select the appropriate converter for a given application especially in terms of resolution and speed. They will afford a real-case situation where an input analog signal must be pre-processed and filtered before the converter stage. They will also learn the main communication protocols to interface with converters and other programmable integrated circuits (SPI, I2C, etc.).

Level 3: this module will offer some details about other components useful to afford the design of more complex systems. Based on the knowledge of the two preceding modules, students will be ready to design circuits intended as more or less standard building blocks for complex applications, determining the design parameters and selecting the best options vs. the case study. Examples of real-life schematics will offer a good dictionary of solutions that the student can add to a library for future use in the real life. It will be then the time to go into some insights of the electronic design with a series of good and bad circuits to analyze and discuss, exploiting what learned till now and being ready to understand what are the best practices of "the art of electronics".

Level 4: this module is intended as the natural final stage of the preceding learning. Here the student will learn Kicad, a cross platform and Open Source electronics design automation suite. We will start with the circuit schematics, then adding a physical footprint to each component , defining a set of PCB rules to respect while routing and finally designing the corresponding Printed Circuit Board, up to the generation of the fabrication output files ready to be sent to a PCB facility.

WHO

Teacher:

Marco Sartore, 3472207478, Via Roma 10 – 57030 Marciana (LI)

HOW

Teaching Methods

Classes will be held in a Laboratory and formed by two intersected types:

- taught-lessons to offer a clear explanation of the theoretical foundations and methods of circuit design (at the various Levels enumerated above)
- practical-lessons where students will be guided to physically realize the explained circuits using a set of provided components, performing all the measurements to test and verify them by means of provided instruments.

Exam Description

The students will be asked to design a final circuit, realize it in the Labs and demonstrate its proper operation with the necessary measurements. They will write a report describing the application circuit and the related results.

Assessment Methods

Continuous assessment throughout the course with verification of students' interest and care, plus a final evaluation of the exam result and report.

WHERE AND WHEN

Lesson Location

Lessons will be done @ UNIGE

Lesson Schedule

January	24th to 28th	Level 1 from 9:00 to 12:00
February	7th to 11th	Level 2 from 9:00 to 12:00
February	21th to 25th	Level 3 from 9:00 to 12:00
March	7th to 11th	Level 4 from 9:00 to 12:00

Office hours for students

Students can ask info to the teacher by phone, email or asking for an appointment.

CONTACTS

Students can write to marco.sartore@edu.unige.it or can freely phone to +393472207478 either to ask information or to arrange for an appointment.

The course has an operational cost of € 250,00 for the Phd students and € 500,00 for external students.

The cost for the Phd students will be covered using the Phd student budget.

Motion control drivers

Scientific Disciplinary Sector: ING-INF/01

Number of hours: 48 (divided in 4 Levels of 12 hours each)

Credits: 3 per Level

AIMS AND CONTENTS

Learning Outcomes (short)

Level 1: Stepper Motors and their drivers - basics Level 2: Stepper Motors advanced topics

Level 3: Brushless Motors and their drivers - basics Level 4: Brushless Motors advanced topics

Learning Outcomes (further info)

Level 1: learning how a Stepper Motor is composed and how it must be correctly driven, combining its mechanical features with driver's requirements, up to the realization of a simple electronic circuit to interface a Stepper Motor.

Level 2: understanding the insights of fine drivers for Stepper Motors, learning microstepping techniques and their practical application in the physical realization of an advanced driver.

Level 3: understanding the structure of Brushless Motors as compared with the brushed ones, their driving needs and how to fulfill their requirements, with the practical realization of a simple driver using dedicated integrated circuits.

Level 4: learning the details of Brushless Motors drivers up to programming a microcontroller as the smart portion of an advanced driver.

Syllabus/Content

Level 1: students will learn the internal structure of a Stepper Motor and its physical pros and cons in motion control applications. Then we will focus on drivers and learn how to design a simple circuit making use of dedicated integrated circuits. Students will learn how to program a software to instruct the driver circuit, thus getting on-field experience of a practical application.

Level 2: students will exploit the acquired concepts into a more advanced design, where the driver will no longer be a dedicated IC but a programmable microcontroller or IC. They will then realize a real driver where

micro stepping will be applied and they will get a fine positioning of the motor. Torque/speed and acceleration issues will be also addressed.

Level 3: this module will offer the basic details about Brushless Motors, including their internal structure and function. Students will learn which signals are needed to properly drive such motors and will design a simple real circuit to test in practice, making use of dedicated integrated circuits.

Level 4: as for Level 2 above, students will take advantage of the acquired concepts and skills towards a more complex design where they will learn how to implement all the blocks needed in a software for a microcontroller. Among these blocks they will figure out how to deal with Clarke and Park transforms and will finally realize an advanced driver to test in practice.

WHO

Teacher:

Marco Sartore, 3472207478, Via Roma 10 – 57030 Marciana (LI)

HOW

Teaching Methods

Classes will be held in a Laboratory and formed by two intersected types:

- taught-lessons to offer a clear explanation of the theoretical foundations and methods of circuit design (at the various Levels enumerated above)
- practical-lessons where students will be guided to physically realize the explained circuits using a set of provided components, performing all the measurements to test and verify them by means of provided instruments.

Exam Description

The students will be asked to realize the described drivers in the Labs and to demonstrate their functioning when connected to a test motor, performing the necessary measurements. They will write a report describing the driver(s) and the related results.

Assessment Methods

Continuous assessment throughout the course with verification of students' interest and care, plus a final evaluation of the exam result and report.

WHERE AND WHEN

Lesson Location

Lessons will be done @ UNIGE

Lesson Schedule

Lessons will be offered during 4 weeks (from Monday to Friday) in January, February, March 2022 with the following schedule:

January	24th to 28th	Level 1 from 14:00 to 16:00
February	7th to 11th	Level 2 from 14:00 to 16:00
February	21th to 25th	Level 3 from 14:00 to 16:00
March	7th to 11th	Level 4 from 14:00 to 16:00

Office hours for students

Students can ask info to the teacher by phone, email or asking for an appointment.

CONTACTS

Students can write to marco.sartore@edu.unige.it or can freely phone to +393472207478 either to ask information or to arrange for an appointment.

The course has an operational cost of € 250,00 for the Phd students and € 500,00 for external students.

The cost for the Phd students will be covered using the Phd student budget.

C++ programming techniques

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) or remotely through Teams platform.

Lesson Schedule

23th, 24th, 25th ,28th ,30th March 2021 and 1st April 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

Mechanical Drawing Fundamentals

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 *(if possible due to Covid Emergency, otherwise online using MS Teams)*

Exam Description: Written test with multiple answer questions

Assessment Methods: In order to obtain the 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

Monday, 17th January 2022, 9-12

Tuesday, 18th January 2022, 9-12

Wednesday, 19th January 2022, 9-12

Thursday, 20th January 2022, 9-12

Monday, 24th January 2022, 9-12

Tuesday, 25th January 2022, 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

Scientific Disciplinary Sector: ING-IND/15

Number of hours: 12 hours

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes (short)

The aim of the course is to gain and apply knowledge of 3D CAD concepts and techniques by using high-end CAD systems (*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, 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 part 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.
- Geometry preparation techniques for structural simulations and basic simulations with integrated tools (*Creo Simulate*).

The level of deepening of each topis will depend on average previous knowledge level of the class.

WHO

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

HOW

Teaching Methods:

The course will be based on 3 hands-on lectures. Slides of the course will be provided.

No previous knowledge of any CAD system is required, but for the best results it is suggested to have basic concepts of mechanical drawing (for reference see the *Mechanical Drawing Fundamentals* Phd course program).

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 …. (contact the teacher for room confirmation)

Lesson Schedule

30, 31 May 2022; 1 June h 15-19

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

Robotic Virtual Prototyping Design

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 6 credits if he/she attends the entire course and accomplishes the final project. This course is the propaedeutic for of the "Mechatronics & AI" and that let the student accomplish the knowledge about the robotic modelling: from the kinematics and dynamics to the control and optimization.

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 worldwide mechanical numerical simulation 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), Multibody Simulation (MBS)
- class 2 (C2)
  - Anthropomorphic Arm Modelling (FEA+MBS)
- class 3 (C3)
  - Anthropomorphic Arm Modelling (MBS + FEA)
- class 4 (C4)
  - Anthropomorphic Arm Modelling (MBS + FEA + Co-Simulation Control)
- class 5 (C5)
  - Anthropomorphic Arm Modelling (MBS+ FEM + Co-Simulation Control+ Optimisation)
- class 6 (C6)

- Final Project Assignment and Development

WHO

Teachers:

Mariapaola D'Imperio	*0102896562*	*mariapaola.dimperio@iit.it*
Ferdinando Cannella	*0102896562*	*ferdinando.cannella@iit.it*
Haider Abidi	*0102896330*	*syed.abidi@iit.it*

HOW

Teaching Methods

Methods

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

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, 1971.

Remarks

Weekly homework will be assigned at the end of each lecture with an estimated average workload of 3 hours per week. Nevertheless the Project Assignment has an estimated average workload of 2-3 days.

- the minimum attendance is 4 out 6 classrooms;
- 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 10 weeks (31st August 2022) 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)
    4) merged with that one of "Mechatronics & AI"

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 rigid and flexible conditions
- PowerPoint presentation (according to the provided template)

WHERE AND WHEN

Lesson Location

In presence: Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova. The Meeting room will be communicate to the attendees two weeks in advance the course.
Online: via Teams call conference (the student will receive the link)

Lesson Schedule

Monday 06th June 2022 14:30-17:30
Tuesday 07th June 2022 14:30-17:30
Wednesday 08th June 2022 14:30-17:30
Monday 13th June 2022 14:30-17:30
Tuesday 14th June 2022 14:30-17:30
Wednesday 15th June 2022 14:30-17:30

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 August 2022

CONTACTS

The Teachers' office is in Unità di Robotica Industriale at 4th floor at Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova.

Mariapaola D'Imperio	*0102896562*	*mariapaola.dimperio@iit.it*
Ferdinando Cannella	*0102896562*	*ferdinando.cannella@iit.it*
Haider Abidi	*0102896330*	*syed.abidi@iit.it*

Mechatronics and AI

Scientific Disciplinary Sector:

Number of hours: 18 hours

Credits: 6 CFU

AIMS AND CONTENT

Learning Outcomes (short)

The goal of the Mechatronics and Artificial Intelligence is aimed at giving an overview about mechatronics system design, artificial intelligence and its applications to mechatronics. The course will be divided into two parts. The first section will deal with the modeling and control of robots, including forward and inverse dynamics. The second part will start with an introduction to AI and will cover different aspects of machine learning, culminating towards modeless control of robots via learning methods. The student gets 6 credits if he/she attends the entire course and accomplishes the final project. This course is the continuation of the "Robotic Virtual Prototyping Design" and that let the student accomplish the knowledge about the robotic modelling: from the kinematics and dynamics to the control and optimization.

Learning Outcomes (further info)

Understanding mechatronics is becoming essential for the engineers of today, since almost all automation systems, from industries to home appliances, utilize mechatronics for their proper functioning. A proper understanding of the modeling of mechatronics systems gives us a powerful tool to improve the performances of our systems.

At the same time, traditional modeling methodologies sometimes are too complex to be implemented. One may use another powerful tool developed in recent years that can come to the rescue there, named Artificial Intelligence. Although AI in itself is a very diverse topic, with many applications, the course will focus on obtaining an overview about AI and machine learning and how we can apply AI to aid in the control of mechatronic systems.

The course will provide a foundation for the students to explore modeling and control, expanding their understanding and horizons. MatLab and Simulink will be used for modeling and control exercises. Python will be used for AI based exercises.

Syllabus/Content

- class 1 (C1)
  - Overview on Modeling, Forward and Inverse Dynamics
- class 2 (C2)
  - Control theory and application to robotic systems
- class 3 (C3)
  - Simulations and test cases of modelling and control
- class 4 (C4)
  - Introduction to AI and deep learning
- class 5 (C5)
  - Transfer learning and reinforcement learning
- class 6 (C6)
  - Final Project Assignment and Development of modeless controllers

WHO

Teachers:

Ferdinando Cannella	*0102896562*	*ferdinando.cannella@iit.it*
Haider Abidi	*0102896330*	*syed.abidi@iit.it*

Teacher assistant:

Gabriele Marchello	*0102896562*	*gabriele.marchello@iit.it*

HOW

Teaching Methods

Methods

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

Prerequisites

Basic knowledge: classical physics and programming.

Installed Software: MatLab/Simulink should be already installed before the lectures. Python will also be used, it is preferable if the students have this installed, otherwise a quick installation guide will be given before the lectures.

Reading List

- Robotics: Modelling, Planning and Control, Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo Springer,1st ed. 2009
- A Mathematical Introduction to Robotic Manipulation, R.M.Murray et al, 1994
- Hands-On Machine Learning with Scikit-Learn, Keras, and Tensorflow: Concept, Tools, and Techniques to Build Intelligent Systems, Aurelien Geron, O'Reilly 2019
- Reinforcement Learning: Industrial Applications of Intelligent Agents, Phil Winder, O'Reilly, 2020

Remarks

Weekly homework will be assigned at the end of each lecture with an estimated average workload of 3 hours per week. Nevertheless the Project Assignment has an estimated average workload of 2-3 days.

- the minimum attendance is 4 out 6 classrooms;
- 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 10 weeks (31st August 2022) 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)
    4) merged with “Robotic Virtual Prototype Design” course

Assessment Methods

The Students should provide the:

- Simulation of systems with and without control loops
- Solutions of AI-based problems
- PowerPoint presentation (according to the provided template)

WHERE AND WHEN

Lesson Location

In presence: Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova. The Meeting room will be communicate to the attendees two weeks in advance the course.
Online: via Teams call conference (the student will receive the link)

Lesson Schedule

Monday 20th June 2022 14:30-17:30
Tuesday 21stJune 2022 14:30-17:30
Wednesday 22nd June 2022 14:30-17:30
Monday 27th June 2022 14:30-17:30
Tuesday 28th June 2022 14:30-17:30
Wednesday 29th June 2022 14:30-17:30

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 August 2022

CONTACTS

The Teachers' office is in Unità di Robotica Industriale at 4th floor at Istituto Italiano di Tecnologia, Via Morego 30 (Bolzaneto), Genova, while the and Teachers assistent is reachable via TEAMS.

Ferdinando Cannella	*0102896562*	*ferdinando.cannella@iit.it*
Haider Abidi	*0102896330*	*syed.abidi@iit.it*
Gabriele Marchello	*0102896562*	*gabriele.marchello@iit.it*

Advanced EEG analyses (aEEGa)

Scientific Disciplinary Sector: ING-INF/06

Number of hours: 15 hours

Credits: 5 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 consist 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 ERSP. 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

According to COVID evolution, lessons will be either done remotely through Teams platform or at Center for Human Technologies, Via Enrico Melen 83, Building B,16152 Genova, Italy, IIT Erzelli. In the latter case, the exact room will be later indicated.

Lesson Schedule

- 17/01/2022 10:00 – 13:00
- 19/01/2022 10:00 – 12:00
- 21/01/2022 10:00 – 12:00
- 24/01/2022 10:00 – 12:00
- 26/01/2022 10:00 – 13:00
- 28/01/2022 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

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 (CT) 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 or remotely through Teams application

Lesson Schedule

- 18th April 09:00 – 12:00
- 20th April 09:00 – 12:00
- 21st April 11:00 – 13:00
- 22nd April 11:00 – 13:00
- 25th April 11:00 – 13:00
- 27th April 10:00 – 13:00
- 29th April 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.

An introduction to modern neurophysiology: bridging experimental tools and computational strategies to unlock the brain

Scientific Disciplinary Sector:

Number of hours: 12 (including assessment)

Credits: 4

AIMS AND CONTENT

Learning Outcomes (short)

The recent convergence between experimental and computational tools is vital to uncover fundamental principles of brain function that have been inaccessible for decades. The course includes both a theoretical and a practical part. Overall, students will learn how to apply computational methods to the modelling and the analysis of neurophysiological data obtained using the most advanced experimental tools currently available.

Learning Outcomes (further info)

Dramatic technological developments have recently allowed neurophysiologists to measure and manipulate brain activity from more individual neurons than ever, simultaneously. Such experiments provide a complex and multidimensional picture of the brain. To navigate such complexity, new data-analysis approaches, as well as theoretical tools, must be developed. By the end of the course, students will have:

1. Learnt about the principles at the basis of the most advanced techniques currently used in neurophysiology (focus on in vivo microscopy, optogenetics, large scale electrical recordings);
2. Explored the most relevant mathematical models of single neurons and neuronal networks, and **worked hands-on** to test them;
3. Gained knowledge of computational strategies to analyze high-dimensional neural data obtained with the techniques in *outcome 1*;
4. Familiarized with relevant literature where computational methods are applied to the analysis of neurobiological data.

Syllabus/Content

h1: single neuron physiology (from action potentials to synapses);

h2: single neuron models of the brain (LIF and generalized LIF) - includes programming homeworks;

h3: modeling synapses, neuronal networks, connectivity matrices - includes programming homeworks;

h4 to h6: the optical revolution: from microscopy to optogenetics, the new tools to read and write brain; activity at high resolution;

h7 to h8: information theoretical strategies applied to the analysis of large-scale brain recordings;

h9 to h10: group presentations and discussion of few seminal papers that have combined experimental and computational strategies to link brain activity to behaviour.

Final assesment

WHO

Teacher(s):

Roberto Maffulli – Istituto Italiano di Tecnologia – roberto.maffulli@iit.it

Mariangela Panniello – Istituto Italiano di Tecnologia – mariangela.panniello@iit.it

HOW

Teaching Methods

Online or in person classes (depending on covid-19 emergency) including 1) presentation slides, 2) group discussion, 3) guided programming tasks (MATLAB).

Exam Description

The final exam will consist in:

1) A programming task to be carried out by students at home in their own time;
2) A written work including a multiple-choice questionnaire and a brief discussion of a research article (2 hours to be allocated)

Assessment Methods

Interest and active participation to the classes will be assessed throughout the course.

Students must be able to at least set up, and possibly complete, the programming assignment.

Minimum 75% correct answers in the questionnaire.

WHERE AND WHEN

Lesson Location

Online or at UNIGE

Lesson Schedule

- February 2nd (09:00-11:00)
- February 3rd (09:00-11:00)
- March 3rd (09:00-11:00)
- March 4th (09:00-11:00)
- March 18th (09:00-11:00)
- March 21st (09:00-11:00)

Office hours for student

Students can contact both teachers via email. If necessary, in person or online meetings will then be arranged.

CONTACTS

Roberto Maffulli – Istituto Italiano di Tecnologia, Via Enrico Melen, 83 - Genova – roberto.maffulli@iit.it

Mariangela Panniello – Istituto Italiano di Tecnologia, Via Morego, 30 - Genova – mariangela.panniello@iit.it

Theory and Practice of Learning from Data

Scientific Disciplinary Sector: ING-INF/05

Number of hours: 20

Credits:5

AIMS AND CONTENT

Learning Outcomes

This course aims at providing an introductory and unifying view of information extraction and model building from data, as addressed by many research fields like DataMining, Statistics, Computational Intelligence, Machine Learning, and PatternRecognition. The course will present an overview of the theoretical background of learning from data, including the most used algorithms in the field, as well as practical applications.

Syllabus/Content

- Inference: induction, deduction, and abduction
- Statistical inference
- Machine Learning
- Deep Learning
- Model selection and error estimation
- Implementation and Applications

References:

- C. C. Aggarwal "Data Mining - The textbook" 2015
- T. Hastie, R.Tibshirani, J.Friedman "The Elements of Statistical Learning: Data Mining, Inference, and Prediction" 2009.
- S. Shalev-Shwartz, S. Ben-David "Understanding machine learning: From theory to algorithms" 2014
- Goodfellow, Y. Bengio, A. Courville "Deep learning" 2016
- L. Oneto "Model Selection and Error Estimation in a Nutshell" 2020

WHO

Teacher(s):

Luca Oneto

email: luca.oneto@unige.it

HOW

Teaching Methods:

Frontal Lessons

Exam Description:

Small presentation (max 30 min) on how the concepts presented in the course ca be used/extended during the student PhD.

Assessment Methods:

Students will be evaluated based on their ability to understand and apply the concepts of the course on a real problem.

WHERE AND WHEN

Lesson Location

Lessons will be performed @ UNIGE and remotely through Teams platform. Room to be confirmed.

Lesson Schedule

From Monday 18th of July to Friday 22nd of July from 8:00 to 12:00 CEST.

Office hours for student

On appointments scheduled by email luca.oneto@unige.it

CONTACTS

On appointments scheduled by email luca.oneto@unige.it

More details at the page https://www.lucaoneto.it/teaching/tpld

An introduction to Body-Machine Interface

Scientific Disciplinary Sector: ING-INF/06

Number of hours: 12 hours

Credits: min 4 CFU

AIMS AND CONTENT

Learning Outcomes (short) The course will introduce the field of body-machine interface (BoMI). It will present different concepts for dimensionality reduction to be applied in the domain of biological signals to control external devices. It will also discuss current scientific and technological perspectives and limitations.

Emphasis will be given to the study of the learning process while using a BoMI both from a modeling and from a data analysis point of view.

Learning Outcomes (further info) Controlling an external device, like a computer or a robotic manipulator, can play a crucial role in improving lives of individuals especially assisting those with motor impairments (Beckerle et al 2017, Park et al 2020) or augmenting the abilities of healthy people (Penaloza et al 2018, Guggenheim et al 2020). In recent years, body-machine interfaces (BoMIs) through a linear or non-linear mathematical function have been proven to be able to transform body signals issued by the user into 2D/3D signals to control an external device like a cursor on a screen (Casadio et al 2011), a virtual and real wheelchair (Thorp et al 2016) or a virtual robotic arm (Rizzoglio et al 2020), and it could be customized to fit the ability of each user.

Syllabus/Content The first part of the course will introduce the general concept of redundancy and its application in body-machine interface and we will do an interactive discussion on the state of the art, highlighting perspective and limitations. We will then analyze more in details linear and non-linear dimensionality reduction techniques to map body movement into a control command for an external device.

In the second part we will approach the BoMI from a modeling point of view, trying to understand how humans solve the dimensionality reduction problem and how they deal with the redundancy while learning to use a BoMI.

WHO

Teacher(s): Camilla Pierella – camilla.pierella@edu.unige.it

HOW

Teaching Methods

Lectures with theory and examples

Exam Description

There will be a final examination decided by the instructor

Assessment Methods

The teacher will evaluate the final examination

WHERE AND WHEN

Lesson Location

The lessons will be done @ UNIGE or remotely through Teams platform

Lesson Schedule

4-5-6-7 July 2022.

Office hours for student

Students can ask info to the teacher by appointments or through e-mail

CONTACTS

camilla.pierella@edu.unige.it

The 3Rs approach in biomedical research and advanced 3D in vitro tissue models.

Scientific Disciplinary Sector: ING-IND/34

Number of hours: 12 hours

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes (short)

Replacement, Reduction, and Refinement:

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.

Advanced 3D in vitro models:

Different biofabrication strategies can be applied to engineer 3D in vitro tissue models by mimicking the structure and function of native tissue through the precise assembly of materials and cells. This approach allows the spatiotemporal control over cell–cell and cell–extracellular matrix communication and thus the recreation of tissue-like structures. Tissue models are applied in regenerative medicine, pharmaceutical, diagnostic, and basic research, reducing the use of laboratory animals according to the 3Rs principle

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
- Scaffold free in vitro models: spheroids, organoids and assembloids.
- Scaffold supported in vitro models: 3D bioprinting and microfluidics.

WHO

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

Donatella Di Lisa, 0103536547, Donatella.Dilisa@edu.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

If possible in presence although trough Teams

Lesson Schedule

12th -15th July, 2022 (10:00-13:00)

Office hours for student

Mail or Teams

CONTACTS

laura.pastorino@unige.it

Donatella.Dilisa@edu.unige.it

Polymers for sustainability, food packaging and biomedics

Unit code: (filled by Unige administrative office)

Scientific Disciplinary Sector: ING-IND/22

Number of hours: 12

Credits: 6

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 and smart 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. Alternative methods to test biomaterials; focus on nanoparticles, microneedles and microfluidic systems for targeted drug delivery.

WHO

Teacher(s):

Giovanni Perotto, giovanni.perotto@iit.it; 010 71781 773

Evie Papadopoulou, paraskevi.papadopoulou@iit.it; 010 71781 705

Giulia Suarato, giulia.suarato@iit.it; 0102896870

HOW

Teaching Methods:

Lectures

Exam Description:

The examination consists in a written test (open questions).

Assessment Methods:

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

WHERE AND WHEN

Lesson Location

Lessons will be done @ IIT or remotely thought Teams platform (depending on the coronavirus situation). The last two modules of the class will be held for sure remotely via Teams platform.

Lesson Schedule

Lessons will be held in May 2022. Six sessions of 2 hours each will be carried on Tuesdays and Thursdays from 10.00 am to 12.00 pm in the following dates: May 3rd and 5th, May 10th and 12th, and May 17th and 19th.

Office hours for student

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

CONTACTS

Teachers' offices are in the 4th floor of the IIT building (via Morego 30, 16163, Genova). Students asking info to the teachers can contact them by email anytime.

Cognitive Robotics for Human-Robot Interaction

Unit code: (filled by Unige administrative office)

Scientific Disciplinary Sector:

Number of hours: 24 hours

Credits: 8 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 useful to make robots able to understand the nonverbal behaviors of the human partner (e.g. facial expressions and body movements) and other perceptual models of cognitive robotics. Further the participants will be provided with an overview on how actions can close the action-perception loop with human partners and how these models integrate in broader cognitive architectures for HRI. The 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 learn how to use computer vision and machine learning techniques to endow the robot with the capability of understanding human behaviors (for instance motion and facial expressions) that are relevant in a 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 for HRI
- Models of Robot Perception and Action in HRI
- Software Development of perception and action models in HRI

WHO

Teacher(s):

Francesco Rea, francesco.rea@iit.it

Ana Tanevska, Ana.Tanevska@iit.it

Joshua Zonca Joshua.Zonca@iit.it

Alessandra Sciutti Alessandra.Sciutti@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) and at the same time the students will be provided with the possibility to attend from remote.

Lesson Schedule

Weeks: from 23th to 27th May from 9 to 12, the 30th and 31st of May and 1st June from 9 to 12.

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, Ana.Tanevska@iit.it,Joshua.Zonca@iit.it, Alessandra.Sciutti@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

Microfluidics and nanofluidics: theory and recent applications

Scientific Disciplinary Sector: ING/INF01, ING/INF06, FIS/07

Number of hours: 12 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 integration of microfluidics with other scientific fields such optics, electronics, or nanotechnologies 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 advanced microfluidics systems through physics and various examples. No prerequisites are required.

Syllabus/Content

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

WHO

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

Dr. Eleonora Perego, +39 3338423226, eleonora.perego@iit.it

HOW

Teaching Methods

Frontal lectures with PPT.

Exam Description

Short thesis or project proposal (2 pages max) dealing with the contents of the course.

Assessment Methods

Evaluation of the thesis/proposal

WHERE AND WHEN

Lesson Location

Lesson will take place @ CHT Erzelli – IIT

Lesson Schedule

4th, 6th, 13th April 10:00-12:00

7th 14th April 14:00-17:00

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, eleonora.perego@iit.it

Robotic technologies for sensorimotor rehabilitation

Scientific Disciplinary Sector: ING-INF/06

Number of hours: 16 hours

Credits: 5 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), 14-15-16 March 2022, time 11-13 and 14-16, (10th floor - room to be decided 1 month in advance)

Campus Erzelli: 4 hours (lab); 17 March 2022, time 11-13 and 14-16 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

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

Introduction to physical Human-Robot Interaction

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), 14-15-16-17 March 2022, time 9-11, (10th floor - room to be decided 1 month in advance)

Campus Erzelli: 4 hours (lab); 18 March 2022, 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

Advanced Fluorescence Microscopy Methods

Scientific Disciplinary Sector: ING-INF/06 and FIS/07

Number of hours: 12

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes (short)

Fluorescence microscopy is an essential tool to investigate and characterize biological specimen in the Life sciences. Modern microscopes offer an increasing range of technical capabilities, such as subdiffractional spatial resolution, and access to unique sample's information, such as the physiology, but thereby become gradually more complex and require appropriate training for correct scientific use. This specialist course provides doctoral students with limited experience in microscopic imaging with the understanding that is needed to use the most advanced fluorescence microscopy techniques.

Learning Outcomes (further info)

Fluorescence microscopy has proven helpful in countless investigations into the mysteries of life. By fluorescence labeling the biomolecules of interest (i.e., the building blocks of the cell), fluorescence microscopy provides a unique window into the physiology of living cells at subcellular spatial resolution and sub-second temporal resolution. Furthermore, the last thirty years have seen a blooming of new advanced microscopy techniques, which can push down these resolution constraints and enrich the sample information obtained from a microcopy experiment. This course will introduce the first microscopy concepts able to double the spatial resolution of conventional microscopy, such as confocal, image scanning, and structure illumination microscopy - while preserving a minimal invasivity on the sample. Together with the spatial, another critical aspect of fluorescence microscopy is the penetration depth. In this context, the course will discuss two-photon excitation microscopy. Successively, the course will introduce the most popular nanoscopy techniques, such as stimulated emission depletion and single-molecule localization microscopy, whose resolution reaches, at least theoretically, the molecule size. The course will continue introducing fluorescence fluctuation spectroscopy, whose primary strength is to investigate biomolecular processes requiring higher temporal resolution than the one affordable by any microscopy imaging techniques. Finally, the course will offer a panoramic in the emerging fluorescence lifetime imaging techniques and their abilities to provide sample functional information.

Syllabus/Content

- Class 1 (2h): Confocal, Two-Photon and Image Scanning Microscopy;
- Class 2 (2h): Structured Illumination Microscopy

- Class 3 (2h): Stimulated Emission Depletion Microscopy;
- Class 4 (2h): Single Molecule Localization Microscopy;
- Class 5 (2h): Fluorescence Lifetime Image Microscopy;
- Class 6 (2h): Fluorescence Fluctuation Spectroscopy

WHO

Teacher(s):

Dr. Giuseppe Vicidomini and Dr. Paolo Bianchini,

+39 010 2897607 and +39 010 2897 613,

giuseppe.vicidomini@iit.it and paolo.bianchini@iit.it

HOW

Teaching Methods:

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

Exam Description:

The examination consists in a brief research project proposal with an oral presentation, and a short test.

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 specified one week before the beginning of the course. Remote option via Teams will be also provided. In case of "social distancing" rules the course will be done only remotely.

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. The lessons are scheduled tentatively for the second and third week of May. The calendar will be confirmed one month before the beginning of the course.

Office hours for student

Dr. Giuseppe Vicidomini and Dr. Paolo Bianchini receive students on Tuesday from 14.30 to 16.00. For the students it is highly requested 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

Dr. Paolo Bianchini

Nanoscopy and NIC@IIT

Italian Institute of Technology

Via Enrico Melen, 83, Edificio B, 16152, Genoa, Italy Office: 12th floor

tel: +39 010 2897 613

e-mail: paolo.bianchini@iit.it

Legal Issues in Bioengineering and Robotics

Bioengineering, A.I. and Robotics: applicable law, contracts and liability.

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

Number of hours: 8

Credits: 3

AIMS AND CONTENT

Learning Outcomes (short)

At the end of the course students will:

- understand the basic legal issues associated with new technologies, A.I. and robotics
- be familiar with European and Italian Product Liability Law with regard to manufacturers, designers and sellers.
- learn how to develop a project compliant with applicable law.
- be aware of the legal effects in order to make a decision in A.I and robotics field

Learning Outcomes (further info)

- *How can we develop models of human-robot interaction that comply with the principles of laws? How can set forth the liability for damages? Who bears the relevant risks? What kind of contracts can we provide?*
- Researchers and professionals in bioengineering, A.I. and robotics often need to 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 complex scenarios in order to reach appropriate decisions.

Syllabus/Content

Topics covered will include:

- Basic concepts of European and National law. Knowledge of legal issues.
- European Parliament Resolution of 20 October 2020 with recommendations to the Commission on a civil liability regime for artificial intelligence (2020/2014(INL)); European Parliament Resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL)); Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (artificial intelligence act) and amending certain union legislative acts. Com/2021/206
- Product Liability and Consumer Protection - Damages
- General Principles of Contract Law and Fundamental rights protection (privacy, accessibility)
- 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 identify and engage with potential legal issues 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

UNIGE

Lesson Schedule

June 9th and 10th (9.00-13.00)

Office hours for student

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

CONTACTS

Students should contact me by email.