PhD Courses offered (2023-2024)

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 (19 Credits)

Ethics and Bioethics in Bioengineering and Robotics[1]	Battistuzzi L.	5
Paper Writing[1]	Marchese M.	5
Grant writing[1]	Leone C.	5
Open Science and Research Data Management (OS&RD)	Pasquale V./Pastorini A.M.	4

Basic Courses

Data acquisition and data analysis methods	Canali C.	2
Mechanical Drawing Fundamentals (BASIC)	Torazza D.	2

Foundation Courses

Programming

C++ programming techniques	Solari F./Chessa M.	6
Computational models of visual perception*	Solari F.	6
Effective habits and skills for successful young scientists	Roli F.	5
Theory and practice of virtual reality systems*	Chessa M.	6
Robot programming with ROS	Recchiuto C.	5
Modern C++	Accame M.	9
Computer aided design	Torazza D.	4
Optics for Microscopy and Spectroscopy	Slenders E. / Zunino 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

[1] Recommended for 2nd and 3rd year students
*Offered by the Phd in Computer Science and Systems Engineering
§ Offered by the Phd in Security Risk and Vulnerability

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
Theatrical techniques for scientific presentation[2]	Sgorbissa A.	5
Vibration Analysis and predictive maintenance	Mottola G.	4

Speciality Courses

Advanced EEG analyses	Inuggi A./Campus C.	5
Research oriented structural and functional neuroimaging	Inuggi A.	5
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

Robot behavior modelling	Colledanchise M.	4
Advanced topics in in-vitro neuroengineering: techniques applications and future directions	Brofiga M.	4
Computational model of visual attention	Schiatti L.	4
Parallel robotics: modelling and analysis	Mottola G.	4

Cognitive Robotics for Human-Robot Interaction	Rea F./ A. Sciutti	5
Artificial Robotic Cognition for the Representation of Purposive Actions	Morasso P.	2
Functional quantitative assessment in sport, ergonomics and rehabilitation	Zenzeri J.	4
Machine Learning Crash Course (MLCC) *	Rosasco L.	6
Deep Learning: a hands-on introduction*	Noceti N.	6
Computer Vision Crash Course*	Odone F.	6
Adversarial Machine Learning	Roli F. / Demetrio L.	3
Effective habits and skills for successful young scientists*	Roli F.	5

Functional quantitative assessment in sport, ergonomics and rehabilitation	Zenzeri J.	4
Robotic Virtual Prototyping Design	Cannella F. /D'Imperio M.	6
Mechatronics and AI	Cannella F. / Marchello G.	6
Photocatalysis and photocatalytic materials	Fazli A.	4
Theory and Practice of Learning from Data§	Oneto L.	5

[2] Recommended for 1st year students

Ethics and Bioethics in Bioengineering and Robotics

Number of hours: 15

Credits: 5

AIMS AND CONTENT

Learning Outcomes

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

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: to develop PhD students' sensitivity to the ethical issues that arise in research and professional practice, and to provide them with knowledge and tools that will help them navigate ethically complex scenarios.

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 research project:
- apply an ethical decision-making framework to ethically problematic scenarios involving questions that are relevant to their research interests.

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

WHO

Teacher(s): Linda Battistuzzi, e-mail: linda.battistuzzi@unige.it.

HOW

Teaching Methods

The course will be delivered using different 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 to solve it or engage with it.

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

Lesson will be held in presence at these classrooms: room G2B except the lessons of January 10th that will be held at room A5

The rooms are located in Via all'Opera Pia, 15A G and Villa Cambiaso:

https://imgur.com/ZKoFN8h

Lesson Schedule

Monday January 8 (15.30 – 17.30)

Wednesday January 10 (15.30 – 17.30)

Friday January 12 (15.30 – 17.30)

Friday January 19 (15.30 – 17.30)

Monday January 22 (15.30 – 17.30)

Wednesday January 24 (15.00 – 17.30)

Friday January 26 (15.00 – 17.30)

Office hours for student

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

CONTACTS

Students should contact me by email: linda.battistuzzi@unige.it.

Grant Writing

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: TBA

Lesson Schedule

- October 7, 2024 (09:00-13:00)
- October 9, 2024 (09:00-13:00)
- October 11, 2024 (09:00-13:00)

Office hours for student

Emails and appointments on request.

CONTACTS

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

Paper Writing

Number of hours: 12 hours

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes (short)

The course aims to provide some basic elements to:

- choose a research topic
- manage and use sources
- do a novel, serious, and useful research
- describe and explain a research

Learning Outcomes (further info)

The Course will be highly interactive and will benefit from the comments of the students.

Syllabus/Content

Research

- What is a scientific activity
- What is a rigorous research?
- To choose a research topic
- To manage and use sources
- To do a novel, serious, and useful research
- To describe and explain a research
- Basic rules of writing
- Scientific language
- Scientific paper structure

WHO

Teacher(s): Prof. Mario Marchese, Ph. +39-010-33-56571 (office) Ph. +39-010-33-52806 (lab)

email: mario.marchese@unige.it

HOW

Teaching Methods

Direct instruction (slides and course material).

Exam Description

The exam will be the drafting of a scientific article, even a short one, which will be reviewed and evaluated by the teacher. It is the only way to get a certificate to get credits. No participation certificate will be issued.

Assessment Methods

Written exam

WHERE AND WHEN

Lesson Location

Online through Office 365 Teams platform

Lesson Schedule

Tuesday January 9, 2024 (15:00-19:00)

Thursday January 11, 2024 (15:00-19:00)

Tuesday January 23, 2024 (15:00-19:00)

CONTACTS

The teacher is available by email (mario.marchese@unige.it).

Theatrical techniques for scientific presentation

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: TBA

Lesson Schedule

- May 3, 2024 (09:00-12:00)
- May 10, 2024 (09:00-12:00)
- May 24, 2024 (09:00-12:00)
- May 31, 2024 (09:00-12:00)

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)

Number of hours: 10

Credits: 4

AIMS AND CONTENT

Learning Outcomes

This training module for PhD Students aims to introduce early-career researchers to the principles of scholarly communication, Open Science and Research Data Management. Students will gain a better understanding of the available research e-infrastructures, tools, and services for Open Access publishing, Research Data Management and FAIR Data. Students will also learn the importance and the transformative potential of Open Science practices in research, especially to improve reproducibility and increase research integrity. They will learn what means to make 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 Data Stewardship Wizard, Zenodo, and Dataverse.

Syllabus/Content

Module 1:

The transformative potential of Open Science for research (V. Pasquale, A. M. Pastorini)

Definition of Open Science; potential and benefits for different stakeholders.

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; support for DMP at 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 (e.g., 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" rules; 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

Frontal 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

UNIGE and IIT (locations TBA)

Lesson Schedule

February 5, 2024 (10:00-12:00)

February 6, 2024 (10:00-12:00)

February 7, 2024 (10:00-12:00)

February 8, 2024 (10:00-12:00)

February 9, 2024 (10:00-12:00)

+ last lecture for Q&A / exam to be decided

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

Office hours for student

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

Data Acquisition and Data Analysis Methods

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

Prerequisites

A basic knowledge of MATLAB® is required. For the lectures in presence, students are also requested to bring their laptops with the following programs installed:

- MATLAB® and the Curve Fitting toolbox
- Arduino IDE

WHO

Teacher(s):

Name: Dr. Carlo Canali

Phone number: +39.010.2896793

Email: carlo.canali@iit.it

Teacher assistant:

to be assigned

HOW

Teaching Methods:

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

Exam Description:

The final lecture of the course will be a laboratory experience using a setup provided by the teachers. The scope is to perform a simple data acquisition & data analysis experience exploiting the knowledge obtained during the course lectures. For this lecture, the presence of the students is mandatory. The students will be required to produce a report about the laboratory experience.

Assessment Methods:

The experimental report will be evaluated by teachers.

WHERE AND WHEN

Lesson Location

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

Lesson Schedule

- June 4, 2024 (09:00-12:00)
- June 11, 2024 (10:00-12:00)
- June 18, 2024 (10:00-12:00)
- June 25, 2024 (10:00-12:00)
- July 2, 2024 (10:00-12:00)
- July 9, 2024 (10:00-12:00)
- July 16, 2024 (10:00-12:00)

CONTACTS

The Teachers' office is at CJIR Laboratory, Via Greto di Cornigliano 4-6r (Campi) Genova. Teachers can be contacted by email or by phone to arrange an appointment.

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

Modern C++

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

Number of hours: 30

Credits: 9

AIMS AND CONTENT

Learning Outcomes (short)

The students will learn the new syntax and philosophy of Modern C++ (releases C++11, -14, -17, -20) with hands on the code at every lesson.

Learning Outcomes (further info)

The course has been renewed by adding the latest new features, hands-on sessions, and useful tools we daily use for our robots in iCub Tech at IIT. The students will learn the latest modern C++ syntax, its application with modern SW development techniques and finally they will challenge themselves with an online assignment where they will put in practice what learnt.

Syllabus/Content

Each of the following modules will be 3.0 hours each with theory and hands-on

1. Introduction 1: presentation of the course, basics of used tools (CMake, gitpod, git, Markdown, etc).
2. Introduction 2: refresh of C++98.
3. The basics 1: nullptr, auto, type aliases, initializer list, uniform initialization
4. The basics 2: range based loops, constexpr, scoped enums, override and final.
5. Advanced topics 1: lambda functions, STL containers, algorithms
6. Advanced topics 2: move semantics, smart pointers.
7. Advanced topics 3: multithread.
8. Advanced topics 4: new features in C++20
9. Language applied 1: hands on code.
10. Language applied 2: Critic discussion and correction of the code assignment.

WHO

Teacher(s):

Marco Accame (coordinator): +39 010 2898201, marco.accame@iit.it

Teachers assistant:

Teacher(s):

Marco Accame (coordinator): +39 010 2898201, marco.accame@iit.it

Valentina Gaggero (valentina.gaggero@iit.it), Nicolo' Genesio (nicolo.genesio@iit.it), Davide Tome' (davide.tome@iit.it).

How

Teaching Methods:

Slides with code examples, hand on code using gitpod or other environment (each student needs a laptop), open discussion and questions.

Exam Description:

An online assignment with some questions and / or development of a simple project using what learned during the course. The goal of the assignment is not to check if a student knows by heart some coding syntax, but to learn how to design and present a piece of work.

Assessment Methods:

To be admitted to the online assignment the student must have attended at least 7 lessons. The assessment is passed if the developed code compiles, produces reasonable results and a simple report is presented.

Where and When

Lesson Location

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

The course will be held in presence.

Lesson Schedule

1. Introduction 1: on **6 May 2024**, 1000-1300
2. Introduction 2: on **8 May 2024**, 1000-1300
3. The basics 1: on **9 May 2024**, 1000-1300
4. The basics 2: on **13 May 2024**, 1000-1300
5. Advanced topics 1: on **15 May 2024**, 1000-1300
6. Advanced topics 2: on **16 May 2024**, 1000-1300
7. Advanced topics 3: on **20 May 2024**, 1000-1300
8. Advanced topics 4: on **22 May 2024**, 1000-1300
9. Language applied 1: on **23 May 2024**, 1000-1300
10. Language applied 2: on **27 May 2024**, 1000-1300

The assignment will be revealed during the course. The students will have some time to complete it and solutions will be critically discussed during the last day 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++]” so that your email can be filtered out and immediately spotted.
- Teams platform after arranged appointment.
- Face to face.

Robot programming with ROS

Number of hours: 15 hours

Credits: 5 CFU

AIMS AND CONTENT

Learning Outcomes

- Learning the ROS communication architecture.
- Applying ROS functionalities to selected case studies.
- Understanding the ROS2 basic concepts.

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. The course will describe in detail the ROS framework, also giving some general operative instructions (classes I – II- III), and it will then deal with some specific aspects (class IV-V), in particular, 3D simulations with ROS and ROS2. The course is particular suggested to students who have never used ROS, which will receive some insights about its features.

The course will foresee the usage of some commonly used robotic simulators, such as Gazebo, giving the possibility of practically testing the ROS features. During the course, a Docker image with ROS and ROS2 already installed will be provided to students.

Syllabus/Content

- Class I (3 hours) – Introduction to ROS Topics. Class examples.
- Class II (3 hours) – Services and Nodes. Class examples.
- Class III (3 hours) – Custom messages and services. ROS Actions. Class examples and Assignment I.
- Class IV (3 hours) – Robot modelling and 3D simulations. Class examples.
- Class V (3hours) – ROS2 Topics, Services and Nodes. Class examples and Assignment II.

WHO

Teacher(s): Prof. Carmine Tommaso Recchiuto, +393480667920, 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 3rd 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

@UNIGE

Lesson Schedule

Monday September 9, 2024,10.00 – 13.00-14:00-17:00

Thursday September 10, 2024, 10:00-13:00- 14:00-17:00

Wednesday September 11, 2024, 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: +393480667920

Mail: carmine.recchiuto@dibris.unige.it

Electronics and Circuits

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 module.

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

The students will be equipped with Kits containing breadboards, components and test instruments to practically experiment on the class' subjects. Personal Computers will NOT be available but are strongly recommended. 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
- 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 circuits, realize them in the Lab and demonstrate their proper operation with the necessary measurements. Drill problems will be submitted during the lessons and the Students will be asked to answer with short reports.

Assessment Methods

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

WHERE AND WHEN

Lesson Location

Lessons will be done @ UNIGE

Lesson Schedule

Lessons will be offered during 2 weeks (from Monday to Friday) in January and February 2024, one module of 12 hours per week, with the following schedule (extremes included):

January 15th to 19th: Module1 and Module 2,

January 15th from 3 PM to 6 PM
January 16th to 18th from 9 AM to 12 AM & from 3 PM to 6 PM
January 19h from 9 AM to 12 AM

February 12th to 16th: Module3 and Module 4,

February 12th from 3 PM to 6 PM

February 13th to 15th	from 9 AM to 12 AM & from 3 PM to 6 PM
February 16h	from 9 AM to 12 AM

Office hours for students

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

CONTACTS

Students can write to sartore@elbatech.com 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

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 circuits based on transistors working as switches, both bipolar and MOSFETs, varying the load connections and operating conditions.
Level 2: 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 3: 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 4: understanding the structure of Brushless Motors and the field oriented control (FOC), with the practical realization of drivers using dedicated integrated circuits, up to programming a microcontroller as the smart portion of an advanced driver.

Syllabus/Content

Level 1: students will work with bipolar and MOSFET transistors learning the insights of their function as switches, which is the basic building block to design motor drivers. They will design, step-by-step, monopolar and multipolar circuits based on discrete parts, in order to get a deep knowledge of drivers.
Level 2: 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 the circuits developed in the preceding Module. Students will start also programming a microcontroller to provide the necessary signals to the discrete drivers.
Level 3: students will exploit the acquired concepts into more advanced designs, where the driver will no longer be made fo dicrete parts but a dedicated IC driven by 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 4: this module will offer the knowledge about Brushless Motors, including their internal structure and function. Students will learn which signals are needed to properly drive such motors and will learn how to design a real circuit, which will be tested in practice with a real motor. Among the advanced topics, they will figure out how to deal with Clarke and Park transforms and will finally realize also the software part of an advanced driver.

WHO

Teacher:

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

HOW

Teaching Methods

The students will be equipped with Kits containing the parts, components and motors to practically experiment on the class' subjects. Personal Computers will NOT be available but are strongly recommended.

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 2 weeks (from Monday to Friday) in June and July 2024, one module of 12 hours per week, with the following schedule (extremes included):

June 10th to 14th: Module1 and Module 2,

June 10th from	3 PM to 6 PM
June 11th to 13th	from 9 AM to 12 AM & from 3 PM to 6 PM
June 14h from	9 AM to 12 AM

July 1st to 5th: Module3 and Module 4,

July 1st from	3 PM to 6 PM
July 2nd to 4th	from 9 AM to 12 AM & from 3 PM to 6 PM
July 5h	from 9 AM to 12 AM

Office hours for students

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

CONTACTS

Students can write to sartore@elbatech.com 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

Number of hours: 20

Credits: 5 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.

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, via Dodecaneso 35

Lesson Schedule

January 29 – February 2, afternoon, a room on the second floor, via Dodecaneso 35.

CONTACTS

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

Mechanical Drawing Fundamentals

Number of hours: 18 hours

Credits: 2 CFU

AIMS AND CONTENT

Learning Outcomes

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.

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

Syllabus/Content

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

WHO

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

HOW

Teaching Methods: Frontal lessons with projected slides

Exam Description: Written test with multiple answer questions

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

WHERE AND WHEN

Lesson Location

Lessons will be held in the following classroom: B8

The room is located in Via all'Opera Pia, B pavillion, 7 in this map: https://imgur.com/ZKoFN8h

Lesson Schedule

Monday, 8th January 2024, 9-13

Tuesday, 9th January 2024, 9-13

Wednesday, 10th January 2024, 9-13

Thursday, 11th January 2024, 9-13

Friday, 12th January 2024, 9-11

Office hours for student

The teacher is available on appointment by phone/mail.

CONTACTS

Teacher's office is located in:

Istituto Italiano di Tecnologia, CRIS

Via San Quirico 19 D, Genova.

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

Computer Aided Design

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). 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

17th, 18th, 19th June 2024, h 14.30-18.30

Office hours for student

The teacher is available on appointment by phone/mail.

CONTACTS

Teacher's office is located in:

Istituto Italiano di Tecnologia, CRIS
Via San Quirico 19 D, Genova.
+39 010 2897 231, Diego.Torazza@iit.it

Robotic Virtual Prototyping Design

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.

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

WHO

Teacher:

Ferdinando Cannella *0102896562* *ferdinando.cannella@iit.it*

Teacher assistant:

to be assigned

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 6^{th} lectures

Prerequisites

Basic knowledge: classical physics and programming.

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

Reading List

- Klaus-Jurgen Bathe, Finite Element Procedures, Prentice-Hall of India, 2009
- Robert D. Cook, David S. Malkus, Michael E. Plecha & Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley & Sons, 2001 (ISBN: 0 471 35605 0)
- Rajiv Rampalli, Gabriele Ferrarotti & Michael Hoffmann, Why Do Multi-Body System Simulation?, NAFEMS Limited, 2011
- R.J.Del Vecchio, Design of Experiments, Hanser Understanding Books, 1971.

Remarks

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

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

Exam Description

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

Assessment Methods

The Students should provide the:

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

WHERE AND WHEN

Lesson Location

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

Lesson Schedule

Tuesday 28th May 2024 14:30-17:30
Wednesday 29th May 2024 14:30-17:30
Thursday 30th May 2024 14:30-17:30
Monday 3rd June 2024 14:30-17:30
Tuesday 4th June 2024 14:30-17:30
Wednesday 5th June 2024 14:30-17:30
Thursday 6th June 2024 14:30-17:30
Friday 7th June 2024, 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 June to the 31st July 2024

CONTACTS

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

Ferdinando Cannella *0102896562* *ferdinando.cannella@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 performance 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

Teacher:

Ferdinando Cannella *0102896562* *ferdinando.cannella@iit.it*

Teacher assistant:

to be assigned

HOW

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 6 weeks (31st October 2024) 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 communicated to the attendees two weeks in advance the course.
Online: via Teams call conference (the student will receive the link)

Lesson Schedule

Monday 16th September 2024 14:30-17:30
Tuesday 17th September 2024 14:30-17:30
Wednesday 18th September 2024 14:30-17:30
Monday 23th September 2024 14:30-17:30
Tuesday 24th September 2024 14:30-17:30
Wednesday 25th September 2024 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 September to the 31st October 2024

CONTACTS

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

Ferdinando Cannella *0102896562* *ferdinando.cannella@iit.it*

Advanced EEG analyses (aEEGa)

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 alberto.inuggi@gmail.com

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

HOW

Teaching Methods:

Projected slides

Exam Description:

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

Assessment Methods:

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

WHERE AND WHEN

Lesson Location

Lessons will be 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

18/03/2024 10:00 – 13:00

20/03/2024 10:00 – 12:00

22/03/2024 10:00 – 12:00

25/03/2024 10:00 – 12:00

27/03/2024 10:00 – 13:00

29/03/2024 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

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 TBA)*
- Class 2 (3h) Introduction to the technical characteristics of the involved hardware 1: magnetic scanner and coils. *(Teacher TBA)*
- Class 3 (2h) Introduction to the technical characteristics of the involved hardware 2: magnetic scanner and coils. *(Teacher TBA)*
- 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, alberto.inuggi@gmail.com

The second teacher will be assigned

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

Location will be defined according to students' number and affiliation

Lesson Schedule

- May 13, 2024 09:00 – 12:00
- May 15, 2024 09:00 – 12:00
- May 17, 2024 11:00 – 13:00
- May 20, 2024 11:00 – 13:00
- May 22, 2024 11:00 – 13:00
- May 24, 2024 10:00 – 13:00
- May 27, 2024 10:00 – 13:00

Office hours for student

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

CONTACTS

Students can contact them by e-mail whenever needed.

Theory and Practice of Learning from Data

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

Who

Teacher(s):

Luca Oneto

email: luca.oneto@unige.it

How

Teaching Methods:

Theoretical lesson plus laboratories in Python using Google Colab https://colab.research.google.com/

Assessment Methods:

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

Where and When

Lesson Location

https://www.lucaoneto.com/teaching/tpld-phd

Lesson Schedule

https://www.lucaoneto.com/teaching/tpld-phd

Contacts

E-mail luca.oneto@unige.it

More details at the page https://www.lucaoneto.com/teaching/tpld-phd

An introduction to Body-Machine Interface

Number of hours: 12 hours

Credits: 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):

Name: Camilla Pierella

Email: 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. Room to be confirmed.

Lesson Schedule

July 3, 2024 (09:00- 12:00)

July 4, 2024 (09:00- 12:00)

July 5, 2024 (09:00- 12:00)

July 6, 2024 (09:00- 12:00)

Office hours for student

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

Contacts

camilla.pierella@edu.unige.it

Advanced Topics in In Vitro Neuroengineering: Techniques, Applications, and Future Directions

Number of hours: 12

Credits: 4

AIMS AND CONTENT

Learning Outcomes

The PhD course is designed to provide students with a comprehensive understanding of in vitro neuroengineering, focusing on the principles, techniques, and applications of engineering approaches for studying and manipulating neuronal systems in vitro. The course will cover fundamental concepts, experimental methodologies, and cutting-edge advancements in the field, with an emphasis on multidisciplinary perspectives. Students will gain practical skills in designing and conducting experiments, and analyzing data.

Syllabus/Content

The course is divided into four sections:

1. Introduction to In Vitro Neuroengineering
    a. Overview of in vitro neuronal systems
    b. Historical context and significance of in vitro neuroengineering
    c. Ethical considerations in in vitro experiments

2. Neuronal Cell Culture Techniques
    a. Cell culture fundamentals
    b. Primary neuronal culture techniques
    c. Induced pluripotent stem cell-derived neuronal cultures
    d. Co-culture systems and organoids

3. Microelectrode Arrays (MEAs)
    a. Principles of MEAs
    b. Fabrication and design considerations
    c. Signal acquisition and data analysis
    d. Applications in electrophysiology and neural interface development

4. Microfluidics and Brain-on-a-Chip Systems
    a. Microfluidic device fabrication and operation
    b. Integration of neuronal cultures in microfluidic platforms
    c. Advancements in drug delivery and chemical stimulation
    d. Disease modeling and high-throughput screening

WHO

Teacher(s):

Name: Martina Brofiga

Phone number: +39 3880732345

Email: martina.brofiga@dibris.unige.it

HOW

Teaching Methods:

Frontal lessons and hands-on activities

Exam Description:

Project proposal (2 pages max) and presentation of it.

Assessment Methods:

Feasibility of the project and the clarity of the presentation will be both evaluated.

WHERE AND WHEN

Lesson Location

Lessons will be done @ UNIGE

Lesson Schedule

July 8, 2024 (10:00 – 13:00)

July 10, 2024 (10:00 -13:00)

July 12, 2024 (10:00 – 13:00)

July 15, 2024 (10:00 – 13:00)

CONTACTS

On appointments scheduled by email: martina.brofiga@dibris.unige.it

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

Number of hours: 12 hours

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes

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:

Bioprinting 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.

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 and lab activities

Exam Description:

The course will be assessed by a lab project

Assessment Methods:

Evaluation of the lab project

Where and When

Lesson Location

@ UNIGE Room to be confirmed

Lesson Schedule

July 17-18-19 2024 (09:00-13:00)

Contacts

laura.pastorino@unige.it

Donatella.Dilisa@edu.unige.it

Polymers an biopolymers for sustainable future

Number of hours: 12

Credits: 4

AIMS AND CONTENT

Learning Outcomes

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 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 and circular economy, 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 and electrical properties, wetting 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.

WHO

Teacher(s):

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

HOW

Teaching Methods:

Lectures

Exam Description:

The examination consists in a written test (multiple-choice and open-ended questions).

Assessment Methods:

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

WHERE AND WHEN

Lesson Location

Please indicate whether lessons will be done @ IIT, rooms to be defined

Lesson Schedule

Lessons will be in April 2024. Specific dates will be decided in Ferbuary (6 classes of 2 hours).

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

Number of hours: 18 hours

Credits: 6 CFU

Aims and Content

Learning Outcomes (short)

The participants will learn the key aspects regulating the interaction between human and robots, and will have an overview of good features and limitations of currently available platforms for HRI. Students will learn how to conduct an HRI study and which metrics are appropriate to characterize the interaction.
Participants will be provided with an overview of some computer vision 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

Teachers assistant:

to be assigned

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

September 4, 2024 (09:00-12:00)

September 5, 2024 (09:00-12:00)

September 6, 2024 (09:00-12:00)

September 12, 2024 (09:00-12:00)

September 13, 2024 (09:00-12:00)

September 19, 2024 (09:00-12:00)

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

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

Functional quantitative assessment in sport, ergonomics and rehabilitation

Number of hours: 12 hours

Credits: 4 CFUs

AIMS AND CONTENT

Learning Outcomes

The present course will introduce the topic of functional quantitative assessment. This subject is becoming fundamental in all the fields where is important to understand human sensorimotor performance and in general in all the applications where the human is physically in the loop, such as collaborative robotics, wearable robotics, rehabilitation robotics, and many others. The difficulty to quantify human performance is due to the complexity of human behaviour. In fact, the human nervous system is capable of a simultaneous, integrated, and coordinated control of 100-150 mechanical degrees of freedom via tensions generated by about 700 muscles. There is also a different number of sensors (visual, auditory, proprioceptive) and actuators (muscles and skeletal system) to take into account.

The course will initially review the traditional techniques adopted to quantitatively assess human sensorimotor performance in the fields of sport, rehabilitation and ergonomics. In the second part of the course will be deeply analysed all the potential technologies that can be exploited to innovate the traditional techniques, with special emphasis on robotic technologies.

Syllabus/Content

- The concept of functional quantitative assessment and the application scenarios
- Lower limb traditional techniques
- Upper limb traditional techniques
- Lower limb robot-based techniques
- Upper limb robot-based techniques
- New trends and potential future technologies

WHO

Teacher(s): Jacopo Zenzeri, 3408311387, jacopo.zenzeri@rewingtech.com

HOW

Teaching Methods:

Slide presentation and critical discussion of a reading list
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

Lesson Location

DIBRIS, University of Genova (room to be decided)

Lesson Schedule

June 17-18-19 2024, time 9-13

CONTACTS

Jacopo Zenzeri, ReWing s.r.l., 6th floor, Via XII Ottobre 1, 16121, Genova, 3408311387, jacopo.zenzeri@rewingtech.com

Photocatalysis and photocatalytic materials

Number of hours: 12

Credits: 4

AIMS AND CONTENT

Learning Outcomes

Photocatalysts are the type of materials for the exploitation of solar energy to produce a chemical reaction. Therefore, they have been widely used to absorb light and carry out the reactions in CO_2 reduction, hydrogen production, water contaminant degradation, biomass waste photoreforming, etc. In this PhD course, we will discuss the basic concepts of photocatalysis and the approaches to enhance the performance of photocatalysts in absorbing sunlight. Moreover, their synthesis methods, characterization techniques, and application in green energy production and antibacterial properties will be considered. Consequently, the learning outcome is expected to be as follows:

- The overall performance of photocatalysts.
- The principles of using different methods, such as using metal or non-metal dopants in the structure of photocatalysts or preparing Z-scheme photocatalysts to boost the efficiency of the semiconductors in absorbing sunlight.
- The synthesis methods of photocatalysts from a lab and industrial scale point of view.
- Various structural and morphological characterization methods for evaluating the so-synthesized photocatalysts.
- Application of photocatalysts in the production of hydrogen as a storable, fossil-free energy source.
- Applications of photocatalysts as antibacterial materials.

Syllabus/Content

- **Concept of single-component photocatalysts**: The performance of semiconductors in absorbing light and electron-hole excitation will be discussed. The concept of band gap energy, valance band, conduction band, charge carrier separation, work function, fermi levels, etc., will be described.
- **Approaches in enhancing the performance of single-component photocatalysts**: Different methods, such as doping metal or non-metal to the structure of photocatalysts and preparing the Z-scheme heterojunctions from coupling two semiconductors, will be discussed. The mechanism of each method in reducing the bandgap of photocatalysts, separating electron-hole, and finally increasing the overall performance of the system will be demonstrated with the schematic figures.
- **Synthetic methods:** The widely used synthesis methods, such as the sol-gel process, hydrothermal and solvothermal techniques, direct oxidation reactions, sonochemical methods, microwave methods,

etc., will be discussed. Moreover, the effect of each method on the variation of the photocatalytic properties will be considered.

- **Structural and morphological characterization:** X-ray diffraction, scanning or transmission electron microscopy, X-ray photoelectron spectroscopy, UV/VIS, infrared and Raman spectroscopies, and Brunauer-Emmett-Teller surface area analysis will be considered in discussions.
- **Application of photocatalysts in the energy sector:** We will discuss using sustainable photocatalysts to apply sunlight and split water into hydrogen and oxygen. The advances in this field and limitations of the photocatalytic reactions in generating hydrogen will be discussed from the industrial point of view.
- **Application of photocatalysts as antibacterial materials:** We will discuss the use of photocatalysts in the fabrication and use of antibacterial materials. The production of reactive oxygen species (ROS) and the different kinetics analysis applied to photocatalytic degradation of organic pollutants.
-

WHO

Teacher(s):

Arezou Fazli, arezou.fazli@iit.it

HOW

Teaching Methods:

Lectures

Exam Description:

The examination consists of a written test (multiple-choice and open-ended questions).

Assessment Methods:

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

WHERE AND WHEN

Lesson Location

Lessons will be done @ IIT

Lesson Schedule

Lessons will be in May 2024. Specific dates will be decided in Ferbuary (6 sessions of 2 hours).

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.

Deep Learning: a hands-on introduction

Number of hours: 20

Credits: 6

AIMS AND CONTENT

Learning Outcomes

Deep Learning (DL) is a branch of Machine Learning that has recently achieved astonishing results in several different domains. This course will provide a hands-on introduction to DL, starting from its foundations and discussing the various types of deep architectures and tools currently available. The theoretical classes will be coupled with hands-on activities in lab (in Python using Keras), which will constitute an integral part of the course, giving the possibility of practicing deep learning with examples from real-world applications, with particular focus on visual data. Besides well-established approaches, the course will also highlight current trends, open problems, and potential future lines of research.
Although the DL course can be taken independently, for the second year it will be held in synergy with the "Computer Vision Crash Course" (CVCC). Computer Vision is indeed one of the most classical and effective applications of DL in the real world. Contributions from the CVCC course will constitute a complementary deepening on basic principles of computer vision and visual perception in artificial agents, but also providing a guided tour using deep learning for computer vision problems.

Syllabus/Content

Core DL Program (for those attending the DL course only)

	DAY1	DAY2	DAY3	DAY4	DAY5
9:00-9:30	Welcome				
9:30-11:00	DL intro		CNN	GANs	Group Project
11:00-11:30	Coffee break		Coffee break	Coffee break	Coffee break
11:30-13:00	Image proc. Intro		Applications	LAB	Group Project
13:00-14:30	Free lunch		Free lunch	Free lunch	Free lunch
14:30-16:00	LAB		LAB	Transformers	Group Project
16:00-16:30	Coffee break		Coffee break	Coffee break	Closing
16:30-18:00	Intro to Group Project		Poster session and ape	LAB	

Both | DL only

Integrated DL and CVCC program

	DAY1	DAY2	DAY3	DAY4	DAY5
9:00-9:30	Welcome				
9:30-11:00	DL intro	Image features	CNN	GANs	Group Project
11:00-11:30	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11:30-13:00	Image proc. Intro	LAB	Applications	LAB	Group Project
13:00-14:30	Free lunch	Free lunch	Free lunch	Free lunch	Free lunch
14:30-16:00	LAB	Motion+Depth	LAB	Transformers	Group Project
16:00-16:30	Coffee break	Coffee break	Coffee break	Coffee break	Closing
16:30-18:00	Intro to Group Project	LAB	Poster session and ape	LAB	

Both | CVCC only | DL only

WHO

Teachers:

Name: Nicoletta Noceti

Phone number: +39 010 3536704

Email: Nicoletta.noceti@unige.it

Name: Francesca Odone

Phone number: +39 010 3536667

Email: Francesca.odone@unige.it

How

Teaching Methods: Theoretical classes and hands-on activities

Exam Description: a group project, whose goal is to suggest the use of one (or more) methodology studied in the course in real-world applications. The project is presented at the end of the course with slides

Assessment Methods: the feasibility of the proposed task and the clarity of the presentation will be both evaluated.

Where and When

Lesson Location

Classes will be in presence in via Dodecaneso 35, 16146, Genova. The room will be defined in due time

Lesson Schedule

June 10- 14, 2024

Contacts

Giulia Casu (MaLGa lab manager), giulia.casu@ext.unige.it

Computer Vision Crash Course

Number of hours: 20

Credits: 6

AIMS AND CONTENT

Learning Outcomes

Visual perception, as a key element of Artificial Intelligence, allows us to build smart systems sensitive to surrounding environments, interactive robots, video-cameras with real time algorithms running on board. With similar algorithms, our smart phones can log us in by recognizing our face, read text automatically, improve the quality of the photos we shoot. At the core of these applications are computer vision models, often boosted by machine learning algorithms.

This crash course is conceived as a complement to the "Deep Learning: Hands on introduction" course (henceforth DL) although it can be taken independently.

It covers the basic principles of computer vision and visual perception in artificial agents, including theoretical classes, application examples, hand-on activities.

Within CVCC, we present elements of classical computer vision (introduction to image processing, feature detection, depth estimation, motion analysis).

At the same time, by borrowing from DL, we also present deep learning approaches to computer vision problems such as image classification, detection, and semantic segmentation.

Syllabus/Content

Core DL Program (for those attending the CVCC course only)

	DAY1	DAY2	DAY3	DAY4	DAY5
9:00-9:30	Welcome				
9:30-11:00	DL intro	Image features	CNN		Group Project
11:00-11:30	Coffee break	Coffee break	Coffee break		Coffee break
11:30-13:00	Image proc. Intro	LAB	Applications		Group Project
13:00-14:30	Free lunch	Free lunch	Free lunch		Free lunch
14:30-16:00	LAB	Motion+Depth	LAB		Group Project
16:00-16:30	Coffee break	Coffee break	Coffee break		Closing
16:30-18:00	Intro to Group Project	LAB	Poster session and ape		

	Both	CVCC only

Integrated DL and CVCC program

	DAY1	DAY2	DAY3	DAY4	DAY5
9:00-9:30	Welcome				
9:30-11:00	DL intro	Image features	CNN	GANs	Group Project
11:00-11:30	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11:30-13:00	Image proc. Intro	LAB	Applications	LAB	Group Project
13:00-14:30	Free lunch	Free lunch	Free lunch	Free lunch	Free lunch
14:30-16:00	LAB	Motion+Depth	LAB	Transformers	Group Project
16:00-16:30	Coffee break	Coffee break	Coffee break	Coffee break	Closing
16:30-18:00	Intro to Group Project	LAB	Poster session and ape	LAB	

	Both	CVCC only	DL only

WHO

Teachers:

Name: Francesca Odone

Phone number: +39 010 3536667

Email: Francesca.odone@unige.it

Name: Nicoletta Noceti

Phone number: +39 010 3536704

Email: Nicoletta.noceti@unige.it

How

Teaching Methods: Theoretical classes and hands-on activities

Exam Description: a group project, whose goal is to suggest the use of one (or more) methodology studied in the course in real-world applications. The project is presented at the end of the course with slides

Assessment Methods: the feasibility of the proposed task and the clarity of the presentation will be both evaluated.

Where and When

Lesson Location

Classes will be in presence in via Dodecaneso 35, 16146, Genova. The room will be defined in due time

Lesson Schedule

June 10-14, 2024

Contacts

Giulia Casu (MaLGa lab manager), giulia.casu@ext.unige.it

Adversarial Machine Learning

Number of hours: 12

Credits: 3

AIMS AND CONTENT

Learning Outcomes

Today machine-learning algorithms are used for many real-world applications, including image recognition, spam filtering, malware detection, biometric recognition. In these applications, the learning algorithm can have to face intelligent and adaptive attackers who can carefully manipulate data to purposely subvert the learning process. As machine learning algorithms have not been originally designed under such premises, they have been shown to be vulnerable to well-crafted attacks, including test-time evasion and training-time poisoning attacks (also known as adversarial examples). In particular, the security of cloud-based machine-learning services has been questioned through the careful construction of adversarial queries that can reveal confidential information on the machine-learning service and its users. This course aims to introduce the fundamentals of the security of machine learning, the related field of adversarial machine learning, and some techniques to assess the vulnerability of machine-learning algorithms and to protect them from adversarial attacks. We report application examples including object recognition in images, biometric identity recognition, spam and malware detection, with hands-on on attacks against machine learning and defences of machine-learning algorithms using the SecML software library, https://secml.readthedocs.io/en/v0.15/.

Syllabus/Content

1. Introduction to adversarial machine learning: introduction by practical examples from computer vision, biometrics, spam, malware detection.
2. Design of learning-based pattern classifiers in adversarial environments. Modelling adversarial tasks. The two-player model (the attacker and the classifier). Levels of reciprocal knowledge of the two players (perfect knowledge, limited knowledge, knowledge by queries and feedback). The concepts of security by design and security by obscurity
3. System design: vulnerability assessment and defense strategies. Attack models against machine learning. Vulnerability assessment by performance evaluation. Taxonomy of possible defense strategies.
4. Hands-on classes on attacks and defences of machine-learning algorithms using the SecML open-source Python library for the security evaluation of machine learning algorithms (https://secml.readthedocs.io/en/v0.15/).
5. Summary and outlook. Current state of this research field and future perspectives

WHO

Teacher(s):

Name: Fabio Roli

Phone number: 320 4372999

Email: fabio.roli@unige.it

Name: Luca Demetrio

Email: luca.demetrio.roli@unige.it

HOW

Teaching Methods: Lectures. The lecturer will use slides. Copies of slides will be provided to the students. Hands-on classes on attacks and defences of machine-learning algorithms using the SecML open-source Python library for the security evaluation of machine learning algorithms (https://github.com/pralab/secml).

Exam Description: 2 written assessments

Assessment Methods: 2 written assessments with open-ended questions

WHERE AND WHEN

Lesson Location

online on MS Teams

Lesson Schedule

July 3-5 2024, 3 half-days, 09 – 13:00 a.m.

CONTACTS

Fabio Roli

DIBRIS, Via Dodecaneso 35, Room 207

Email: fabio.roli@unige.it

Luca Demetrio

Email: luca.demetrio.roli@unige.it

Effective habits and skills for successful young scientists

Number of hours: 20

Credits: 5

AIMS AND CONTENT

Learning Outcomes

Although tons of books on effective habits and soft skills have been published, they have not been thought for scientists, and, therefore, issues that are relevant for them are not easily available. This short course aims to collect spread ideas and place them in a coherent framework useful for young scientists and provide a small tactical guide for scientists at the first stages of their career. First, I review the main concepts of Steve Covey's personal and time management paradigm, the inspirational speeches of the late Professor Randy Pausch, and the paradigm of atomic habits of James Clear, and discuss their utility for daily activity of a young scientist. Then, I focus on a few practical skills, namely, on how to write a great paper and give a great talk. I try to convey the message that succeeding in science and technology requires skills and habits beyond the pure intelligence and intellectual abilities, and that good habits and skills of personal and time management are extremely important for young scientists.

Syllabus/Content

1. Basic concepts of theory of habits. Effective habits for young scientists.
2. Basis concepts of personal and time management. Effective personal and time management for young scientists.
3. Survival skills in the game of science. Know yourself: match your goals to your character and talents.
4. How to write a great paper.
5. How to give a great talk.

WHO

Teacher(s):

Name: Fabio Roli

Phone number: 320 4372999

Email: fabio.roli@unige.it

HOW

Teaching Methods: Lectures. The lecturer will use slides. Copies of slides will be provided to the students.

Exam Description: written assessments

Assessment Methods: written assessments with open-ended questions

WHERE AND WHEN

Lesson Location

online on MS Teams

Lesson Schedule

June 24-28 2024, 5 half-days, 09 – 13:00 a.m.

CONTACTS

Fabio Roli

DIBRIS, Via Dodecaneso 35, Room 207

Email: fabio.roli@unige.it

Optics for Microscopy and Spectroscopy

Number of hours: 12 h

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes

Light is an essential tool for many important scientific applications, such as optical microscopy and spectroscopy. This course is intended to provide the essential theoretical background of optics and imaging. In particular, the course will focus on traditional and state-of-the-art optical techniques. Additionally, students will have the opportunity to attend a demonstration with custom-built optical setups. The student will acquire a general overview of the physical principles of modern optical techniques and their most relevant applications.

Syllabus/Content

The course will focus on theory and applications.
A minimum knowledge of mathematics is expected from the students.

Class 1 (2h): Fundamentals of optics (geometrical, scalar, and vectorial optics)

Class 2 (2h): Imaging and wide-field microscopy

Class 3 (2h): Confocal microscopy, Image Scanning Microscopy, STED microscopy

Class 4 (2h): Non-linear optics, multiphoton fluorescence and second harmonic generation microscopy

Class 5 (2h): Fluorescence correlation spectroscopy, fluorescence fluctuation spectroscopy, fluorescence lifetime

Class 6 (2h): Visit of the laboratory and experimental demonstrations

WHO

Teacher(s):

Dr. Eli Slenders, eli.slenders@iit.it, +39 010 28 97 619

Dr. Alessandro Zunino, alessandro.zunino@iit.it, +39 010 28 97 619

HOW

Teaching Methods:

This course requires the active participation of all class members through active listening and discussion. For the lessons, a blackboard and slide presentations will be used. In addition, the course includes a visit to the microscopy laboratory.

Exam Description: The examination will be a short, written test containing multiple questions regarding the key messages of the course.

Assessment Methods: Class attendance and regular participation are required for this course. The assessment will be in written form.

WHERE AND WHEN

Lesson Location

Lessons will take place at the IIT-Center for Human Technology, Via Enrico Melen 83, Building B, Genoa.

Lesson Schedule

The course will be organized into six lessons of two hours each:

March 4, 2024 (10:00-12:00)

March 5, 2024 (10:00-12:00)

March 6, 2024 (10:00-12:00)

March 7, 2024 (10:00-12:00)

March 8, 2024 (10:00-12:00)

March 11, 2024 (10:00-12:00)

CONTACTS

Dr. Eli Slenders

Molecular Microscopy and Spectroscopy

Istituto Italiano di Tecnologia (IIT) – Center for Human Technologies (CHT)

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

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Dr. Alessandro Zunino

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e-mail: alessandro.zunino@iit.it

Artificial Robotic Cognition for the Representation of Purposive Actions

Number of hours: 8

Credits: 2

AIMS AND CONTENT

Learning Outcomes

The new generation of robot for industry 4.0 is supposed to cooperate and communicate with humans in a direct and bidirectional way. In the framework of Cybernetic tradition this implies that humans and robots are characterized by cognitive that are somehow similar, although different for implementation and technological details. The course will clarify the difference between Artificial Intelligence and Artificial Cognition, focusing on the concept of Embodied Cognition, in opposition to mind-body dualism, for representing purposive actions in both humans and robots.

Syllabus/Content

- Cybernetics – Embodied Cognition -Artificial Intelligence
- Optimality of Biological Motion – Space-time invariants
- Degrees of Freedom Problem
- Equilibrium Point Hypothesis
- Neural Simulation of Actions – Motor Imagery - Passive Motion Paradigm
- Symbolic AI vs. Connectionist AI
- Behavioral and Computational Self-organization principles
- Topology Representing Networks – Hopfield Networks
- Neural fields and neuromorphic engineering

WHO

Teacher(s):

Name: Pietro Morasso

Phone number: 3281003224

Email: pietro.morasso@iit.it

HOW

Teaching Methods: Slide presentation and discussion of a reading list

Exam Description: The students will be asked to prepare a short paper (2-3 pages) that describes how the topics covered by the course may impact the development of their doctoral project.

Assessment Methods: Evaluation of the paper

WHERE AND WHEN

Lesson Location

IIT CHT ERZELLI

Lesson Schedule

Four lectures, 2 hours each, second half of October 2024

CONTACTS

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

Machine Learning Crash Course (MLCC)

Number of hours: 20

Credits: 6

AIMS AND CONTENT

Learning Outcomes

Machine Learning is key to develop intelligent systems and analyze data in science and engineering. Machine Learning engines enable intelligent technologies such as Siri, Kinect or Google self-driving car, to name a few. At the same time, Machine Learning methods help deciphering the information in our DNA and make sense of the flood of information gathered on the web, forming the basis of a new "Science of Data". This course introduces the fundamental methods at the core of modern Machine Learning. It covers theoretical foundations as well as essential algorithms. Classes on theoretical and algorithmic aspects are complemented by practical lab sessions.

Syllabus/Content

Tue - 9.30-11.00 - Class 1: - Introduction to Statistical Machine Learning

Tue - 11.30-13.00 - Class 2: - Local Methods and Model Selection

Tue - 14.30-16.30 - Lab 1: - Local Methods for Classification

Wed - 9.30-11.00 - Class 3: - Empirical Risk Minimization with Linear Models

Wed - 11.30-13.00 - Class 4: - Optimization and SGD

Wed - 14.30-16.30 - Lab 2: - ERM with Linear Models

Thu - 9.30-11.00 - Class 5: - Kernel Methods

Thu - 11.30-13.00 - Class 6: - Neural Networks

Thu - 14.30-16.30 - Lab 3: - Kernel Methods and Neural Networks

Fri - 9.30-11.00 - Class 7: Sparsity and variable selection

Fri - 11.30-13.00 - Class 8: Dimensionality Reduction and PCA

Fri - 14.30-16.30 - Lab 4: - Sparsity and PCA

WHO

Teacher(s):

Name: Lorenzo Rosasco, DIBRIS

Email: lorenzo.rosasco@unige.it

Name: Silvia Villa, DIMA

Email: lorenzo.rosasco@unige.it

Name: Giovanni Alberti, DIMA

Email: giovanni.alberti@unige.it

Name: Simone Di Marino, DIMA

Email: simone.dimarino@unige.it

Name: Matteo Santacesaria, DIMA

Email: matteo.santacesaria@unige.it

HOW

Teaching Methods:

The school will take place exclusively in person, it will not be streamed online. Active attendance will be part of the evaluation.

Exam Description:

The test will consist in completing remotely the notebooks that the class will work on during the labs, and a writing a report commenting on the numerical results obtained.

Assessment Methods:

Students will receive a certificate of attendance if they have attended the entirety of the course, and an additional certificate if they pass the test.

WHERE AND WHEN

Lesson Location

DIBRIS, Via Dodecaneso 35

Lesson Schedule

25-28 June 2024

CONTACTS

Students can interact with instructors via email.

Computational models of visual attention

Number of hours: 12

Credits: 4

AIMS AND CONTENT

Learning Outcomes

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

- Describe the basic mechanisms of human visual attention based on eye movements.
- Design an experimental protocol with eye-tracking and select suitable outcome measures.
- Identify, train and visualize the output of ANNs suitable to model human visual attention.
- Discuss the choice of different ANNs architectures based on a specific application.
- Present a project idea and discuss their scientific hypothesis and methodological choices.

Syllabus/Content: The course is designed to provide students with an overview of existing computational methods to model human and machine attention during visual tasks (e.g. object recognition, visual search, detection of social cues). During the first part of the course, students will gain a basic background about human visual attention mechanisms based on gaze data, as well as advantages and limitations of existing eye-tracking technologies. Second, they will learn how to incorporate attention mechanisms into the most common ANNs' architectures, and to interpret both human and machine attention on visual tasks. Hands-on sessions will help students to gain a quick, practical experience in building computational models of visual attention. The course will conclude with a project proposal presentation with feedback from the instructor and the other students.

WHO

Teacher(s):

Name: Lucia Schiatti

Email: lucia.schiatti@iit.it; schiatti@mit.edu

HOW

Teaching Methods: The course is composed by 3 lectures, including both a theoretical presentation of the content and a practical hands-on session. Hands-on sessions will include software exercises implemented in Python. The final lecture will be devoted to the student projects' presentation and discussion.

Exam Description: Students will be required to prepare a project proposal about one potential application of the methods presented during the course, and to set up a methodological approach for implementation. Students' projects will be presented through a pitch session during the last lecture.

Assessment Methods: Students' will be encouraged to actively participate to the lectures through small groups' activities and discussions. They will practice the learned concepts through software lab exercises with incremental complexity. For the summative assessment, students will be required to prepare a final project proposal and to present it at the end of the course.

WHERE AND WHEN

Lesson Location: @whatever (either @IIT or @UNIGE). Room to be confirmed.

Lesson Schedule

April 16, 2024 (9:00-12:00)

April 18, 2024 (9:00-12:00)

April 22, 2024 (9:00-12:00)

May 24, 2024 (9:00-12:00)

CONTACTS

Students can interact with instructors via email.

Vibration analysis and predictive maintenance

Number of hours: 12 hours

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes

Highlights

- Learn the basics of mechanical vibration modeling and measurement
- Apply different techniques (in the time or frequency domain) to analyze vibration data.
- Understand the general concepts of predictive maintenance and how to identify anomalies.

Further info

This course aims to provide students with a comprehensive understanding of mechanical vibrations, their analysis and modeling, and relevant applications for predictive maintenance. Lesson 1 covers the basics of vibration analysis, together with real-world examples from various fields, including robotics. Lessons 2 and 3 offer a brief summary of dynamic analysis of mechanical systems, then delve into vibration modeling for a few example systems. In lessons 4 and 5, students will learn about the specific challenges and methods associated with analyzing vibrations to identify patterns, detect faults and predict the remaining useful life of machinery. Lesson 6 discusses vibration sensors and tools for data collection.

Upon completing this course, students will have a solid understanding of vibration analysis and its role in predictive maintenance, as well as the skills to apply these techniques in real-world scenarios. ***The course is also suggested to students who want to develop a deeper understanding of physical modeling of mechanical systems and their dynamics.***

Exercises will require developing a MATLAB model of some simple vibrating systems.

Syllabus/Content

- Lesson 1 (2 hours) – Introduction to vibration modeling, case studies and practical applications
- Lesson 2 (2 hours) – A refresher on dynamics and vibration modeling for simple systems
- Lesson 3 (2 hours) – Vibration modeling for complex systems and Assignment I
- Lesson 4 (2 hours) – Vibration data analysis
- Lesson 5 (2 hours) – General maintenance concepts and vibration-based methods
- Lesson 6 (2 hours) – Vibration sensors and Assignment II

WHO

Teacher: Giovanni Mottola, +393402731224, giovanni.mottola@unige.it

HOW

Teaching Methods. The instructional approach will integrate lectures along with guided exercises to cover the core theoretical aspects. Course slides will be distributed prior to each lecture. Two compulsory assignments will be assigned after the third and sixth sessions.

Exam Description. The assignments involve developing a simple MATLAB model of the dynamics for an example system and a script for analyzing reference vibration data. Some basics of MATLAB programming will also be presented during the course, to show practical implementations of the theory. Subject to availability constraints, some systems for vibration measurement will also be presented in class.

The exam will be a one-on-one discussion with each student about the way the assignments were developed.

Assessment Methods. The code will be evaluated by the teacher in terms of completeness and clarity. In an oral examination, after scheduling an appointment with the teacher, the students will showcase their work. The assessment will consider how the students have learned and applied the techniques taught throughout the course.

WHERE AND WHEN

Lesson Location

@UNIGE (TBA)

Lesson Schedule

July 8, 9, 10, 11, 12, 15 (15:00-17:00)

CONTACTS

Giovanni Mottola, Junior assistant professor (fixed-term), RICE lab @DIBRIS (building E, Via Opera Pia 13, 2nd floor). The teacher may be contacted by mail or by phone

Phone: +393402731224

Mail: giovanni.mottola@unige.it

Parallel robotics: modeling and analysis

Number of hours: 12 hours

Credits: 4 CFU

AIMS AND CONTENT

Learning Outcomes

Highlights

- Develop a comprehensive understanding of parallel robotics systems.
- Master the modeling and analysis techniques for parallel robotics.
- Learn how parallel robots have been applied to real-world problems.

Further info

The course offers a basic understanding of parallel robots and their behavior. Lesson 1 discusses design principles, architectures, practical applications and advantages of parallel robots over serial ones. Lessons 2 and 3 focus on the mathematical modeling of the kinematics for such robots. Lesson 4 shows how to evaluate the performances of parallel robots, compute their workspace and find the singularity loci. Lesson 5 provides an introduction to static and dynamic modeling. Lesson 6 mentions advanced topics such as optimization techniques and calibration. Students of the course will master the modeling and analysis of parallel robots, enabling them to understand (and contribute to) advancements in the field.

The course is also suggested to students who want to develop a deeper understanding of physical modeling and mechanical design of robots in general.

Exercises will require developing MATLAB/SimScape models for some simple parallel architectures.

Syllabus/Content

- Lesson 1 (2 hours) – Design and applications
- Lesson 2 (2 hours) – Inverse and direct kinematics
- Lesson 3 (2 hours) – Motion derivatives, accuracy, kinematic indexes and Assignment I
- Lesson 4 (2 hours) – Workspace and singularities
- Lesson 5 (2 hours) – Static and dynamic modeling
- Lesson 6 (2 hours) – Advanced topics, class examples and Assignment II

WHO

Teacher: Giovanni Mottola, +393402731224, giovanni.mottola@unige.it

HOW

Teaching Methods. The instructional approach will integrate lectures along with guided exercises to cover the core theoretical aspects. Course slides will be distributed prior to each lecture. Two compulsory assignments will be assigned after the third and sixth sessions.

Exam Description. The assignments involve developing a simple MATLAB model of the kinematics and dynamics for two common parallel robot architectures. Some basics of MATLAB programming will also be presented during the course, to show practical implementations of the theory. Subject to time constraints, some basic modeling in SimScape will also be presented, to compare the results from different modeling techniques.

The exam will be a one-on-one discussion with each student about the way the assignments were developed.

Assessment Methods. The code and the simulations will be evaluated by the teacher in terms of completeness and clarity. In an oral examination, after scheduling an appointment with the teacher, the students will showcase their work. The assessment will consider how the students have learned and applied the techniques taught throughout the course.

WHERE AND WHEN

Lesson Location

@UNIGE (TBA)

Lesson Schedule

February 5, 6, 7, 8, 9 (15:00-17:00), 12 (10:00-12:00)

CONTACTS

Giovanni Mottola, Junior assistant professor (fixed-term), RICE lab @DIBRIS (building E, Via Opera Pia 13, 2nd floor). The teacher may be contacted by mail or by phone (see contacts)

Phone: +393402731224

Mail: giovanni.mottola@unige.it