



Module Handbook for M.Sc. Health and Medical Data Analytics

Study track at UGA

**Master on Health Engineering, Study track on Data Analytics
for Precision Medicine**

Please note, that all modules presented are just a selection of elective courses.
For more information, please visit the website of the respective university.

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1.1 1st year, 1st semester (autumn/winter semester)

Innovation and Entrepreneurship 1 (9 ECTS)

INITIATION TO PROJECT MANAGEMENT

Responsible Lecturer: Jean Breton

ECTS: 3

Course type and weekly hours: 16h

Exam type: scientific report, presentation

Content

This course provides a sketch of the traditional method of project management. The model that is discussed here forms the basis for all methods of project management. Later courses go into more depth regarding a model that is particularly appropriate for IT-related projects.

Dividing a project into phases makes it possible to lead it in the best possible direction. Through this organisation into phases, the total workload of a project is divided into smaller components, thus making it easier to monitor. The following paragraphs describe a phasing model that has been useful in practice. It includes six phases:

1. Initiation phase
2. Definition phase
3. Design phase
4. Development phase
5. Implementation phase
6. Follow-up phase

Prerequisites

The plans must not necessarily have a technological characterization. They must economically be viable, but not compulsorily lucrative (partnerships, fair trade, ...).

SCIENTIFIC READING AND WRITING

Responsible Lecturer: Don Martin

ECTS: 3

Course type and weekly hours: 16h

Exam type: scientific report, presentation

This course will introduce the basis to perform good oral and written presentations with several sequences of combined lecture, tutorial, workshop to allow the master students to deal with any situation of their Master 1 year or their future work.

Content

A first sequence will help the students to find an internship. A tutorial and a workshop will be organized in order to improve their CV and practice an interview.

A second teaching sequence will address the way to write a scientific report, from an internship report towards a scientific publication. This part will be followed by a lecture concerning the different modes of scientific communication, written or oral (report, meeting, lab-book, etc) within a laboratory.

A third sequence will deal with oral scientific presentation. A tutorial will explain how to prepare the presentation as well as how to present it. A workshop will give the opportunity to practice in front of an audience. It will also be the basis for an evaluation.

Another lecture will provide an opening towards electronic communication tools in order to be able to succeed in a skype interview and to be visible on the web using tools like LinkedIn or Viadeo.

A closing lecture will offer a transversal view of the different points highlighted throughout the course.

Learning outcomes

Students will improve their skills in written and oral presentation. The course will provide competences required for the Master 1. Students will be trained in order to be able to write their CV and internship report, achieve interviews and be able to provide convincing scientific presentation. These specific points will also be extended to other oral and written communication tools as well as electronic communication that can be needed during and after a Master 2 program.

HMDA Common core (21 ECTS)

MOLECULAR BASES OF HUMAN DISEASES

Responsible lecturer: Arnaud Seigneurin

ECTS: 3

Course type: 22h

Exam type: t.b.d.

Knowledge of the language of human pathology to facilitate dialogue between scientists and medical practitioners. Better integrate in the medical field the scientific and technical knowledge acquired in the IS Master. To show how, from the knowledge of molecular and cellular mechanisms, biotechnologies make it possible to improve the treatment or diagnosis of diseases.

Course examples:

- Pathology Basics
- Mechanisms of HIV and EBV infections
- Molecular and cellular bases of carcinogenesis
- Diabetes and its complications
- Atheroma and cardiovascular diseases
- Place of inflammation in human pathologies
- Cell bases of autoimmune diseases
- Mechanisms of host-pathogen relations: malaria

MOLECULAR TOOLS TO HEALTH

Responsible lecturer: Arnaud Seigneurin

ECTS: 6

Course type: 36h

Presentation of the methods of preparation and transformation of macromolecules (nucleic acids, polysaccharides and analogues): in vitro and in vivo synthesis of DNA, RNA, modified DNA, principles of extraction, purification, manipulation of macromolecules by enzymes, PCR and RTPCR in real time, analytical methods and strategy in molecular biology. Knowledge of vectors: main elements constituting a vector, fast cloning methods, inducible systems, promoter activity control, genomic insertion method, mass spectrometry analysis.

The goals are to acquire:

- a knowledge of the main techniques in molecular engineering
- a knowledge of the chemical and biochemical tools used in biotechnologies using biological polymers (DNA, polysaccharides, etc.).

Examples of interventions

- Synthesis of normal and modified nucleic acids
- Chiral selectors applied to nucleic acids and biological polymers
- NAPs and their use
- Polysaccharides: Preparations, Biotechnological Changes and Sugar-Protein Interactions.
- PCR and RTPCR in real time
- vectors
- DNA analysis: mass spectrometry, sequencing methods, capillary electrophoresis, dHPLC
- Sequencing and sequencing methods for eukaryotic genomes Méthodes de séquençage et séquençage des génomes eucaryotes

PROTEOMICS FOR HEALTH RESEARCH

Responsible lecturer: Sandrine Bourgoïn

ECTS: 3

Course type: IS E-learning (45h)

Exam type: t.b.d.

Proteomics describes large-scale analysis of proteins in a biological sample. The aim of these studies is to determine the protein parts that are present in such samples and to define their concentrations, molecular states, structures, functions or connections. Today, there are different technologies being used and developed to study the different types of samples such as to find biomarker molecules that could help to diagnose diseases or even improve therapy of patients.

Course main content

The objective of the course is to present current trends for global protein analysis and to demonstrate its principles, challenges and complexity. The course will therefore provide an overview of typical proteomics applications used today, such as for biomarker discovery and validation.

The course is focused on different methods, technologies and strategies currently used within the field of proteomics in general and with an emphasis on biomarker discovery.

The lectures will cover background and recent advances for both classical proteomics methods, such as 2D-gel electrophoresis and mass spectrometry, and strategies based on high-throughput antibody generation, bioinformatics and structural approaches.

Intended learning outcomes

The aim of the course is to provide the students with an introduction to current methodologies and trends in the field of proteomics. The students should also obtain an overview and awareness of typical proteomics applications. After completed course the student should be able to describe and discuss the possibilities and advantages, and the complexity and drawbacks of various proteomics technologies compare traditional methods with emerging technologies suggest suitable approaches for specified applications and motivate the choice speculate and argue about the future of proteomics technologies participate in scientific discussions regarding proteomics technologies critically evaluate scientific results

Literature

Principles of Proteomics by R.M Twyman, Garland Science, ISBN: 9780815344728 (second edition)

Handout and articles distributed at the lectures

APPLIED PROBABILITY AND STATISTICS

Responsible lecturer: Anatoli louditski, Sana Louhichi

ECTS: 6

Course type and working hours: 48h

Exam type: Applied proba part (50%), statistics part (50%)

Description

The aim of this course is to provide basic knowledge of applied probability and an introduction to mathematical statistics. Contents of applied probability: Markov Chains: description, properties, applications.

Contents of mathematical statistics:

- Estimation (parameter)
- Sample comparison
- Statistical tests

This course includes practical sessions. Mutualized with M1 SSD Applied probability and Statistics. See the associated content from UPMF.

ALGORITHMS AND SOFTWARE TOOLS

Responsible lecturer: Laurence Pierre

ECTS: 3

Course type and working hours: 36h

Exam type: practical (50%), written exam (50%)

Description

The objective of this course is to present the computer sciences basics useful for applied mathematics.

Contents

1. Compilation (const, inline, loops, Gnu Make ...)
2. C++: genericity (template), code reuse (STL), efficient programming
3. Objects and hierarchical memory, notions of cache and locality (e.g., BLAS)
4. Basics of algorithmics
5. Complexity
6. Error propagation, floating point computing

Prerequisite

UNIX/LINUX. At least some programming languages (C, python, java).

Learning outcome

Produce code using C++, algorithms and compilation tools, taking into account complexity and errors.

SIGNAL AND IMAGE PROCESSING

Responsible lecturer: Cecile Amblard

ECTS: 6

Course type and working hours: 54h

Exam type: practical (50%), written exam (50%)

Description

The aim of this course is to provide the basics mathematical tools and methods of image processing and applications.

Content:

- Image definition
- Fourier transform, FFT, applications
- Image digitalisation, sampling
- Image processing: convolution, filtering. Applications
- Image decomposition, multiresolution. Application to compression

This course includes practical sessions.

Prerequisite

Geometry and analysis from L3 mathematics/applied mathematics

Learning outcomes

Tools for image processing (see objectives above)

1.2 1st year, 2nd semester (spring/summer semester)

Innovation and Entrepreneurship 2 (9 ECTS)

SHORT INTERNSHIP

6 ECTS

Description

Science industrial and/or business project.

Master's electives (21 ECTS)

HIGH THROUGHPUT IN BIOLOGY

Responsible lecturer: Mickael Charrier

ECTS: 6

Course type and working hours: 70h

Exam type: oral exam (50%), Research project (50%)

Course outline

The lectures present the basic methodology and some advanced techniques used for high throughput *in vitro* small molecule drug discovery. The principles and statistical methods used for assay optimization and validation will also be explained.

1. Molecular biology, Biochemistry and Protein expression
2. Proteomic analysis; Mass spectrometry
3. Lab-chips and Cell-chips
4. Structural biology: Crystallogenesis and Crystallization; RMN
5. Combinatory chemistry

Prerequisite

Background in biochemistry, molecular biology and cellular biology. Knowledge in physiology, immunology and microbiology will be appreciated. Students with laboratory and/or practical skills will better understand technological benefits of the use of high throughput technologies in the lab work.

Targeted skills

After completion of this course, students should be able to better understand and compare different high throughput methods used, for instance, for the discovery and validation of new biomarkers.

Be able to present this knowledge in oral and written form.

HOW TO BECOME A CANCER CELL

Responsible lecturer: Arnaud Seigneurin

ECTS: 6

Course type and working hours: 50h

Exam type: t.b.d.

Description

The objective of this course is to acquire the fundamental knowledge necessary to understand key mechanisms of cancer development. This course includes a set of lectures on alterations of cellular and molecular mechanisms that are responsible for the cancer pathophysiology. These modified cellular functions include for example the cell division, apoptosis, gene expression, stem cells, angiogenesis and degradation of the extracellular matrix... The fundamental notions will be illustrated via their implications in diagnosis and therapeutics. The publication analysis will allow emphasizing the medical interest.

Learning outcomes

- Knowledge in fundamental cancer cell biology, cancer cell-host relationship, basis on corresponding targeted therapeutics
- Ability to analyse biological data from published scientific manuscripts.

CANCER DISEASE: EXPERIMENTAL AND THERAPEUTICALLY APPROACHES

Responsible lecturer: Claire Rome

ECTS: 6

Course type and working hours: 40h

Exam type: t.b.d.

Description

To provide a comprehensive overview of cancer from basic research to clinical trials: cancer physiopathology; cancer metabolism; proteomics; circadian rhythm and cancer cell characteristics; development of new anti-cancer drugs; imaging in cancer disease

BIostatISTICS, BIOinformatics, Modelling

Responsible lecturer: Adeline Leclercq-Samson

ECTS: 6

Course type and working hours: 39h

Exam type: Oral exam (60%, 30 min), Research project (20%, 30min)

Course outline

At the end of the course, the students should be able to analyse a "omic" dataset. More precisely, they should be able:

- to load, explore and summarize graphically a dataset;
- to compute confidence interval estimates for proportions, means and variances;
- to formulate hypotheses, compute tests statistics, interpret p-values and make practical decisions for the
- standard parametric and non-parametric tests;
- to adjust simple and multiple linear models, analyses of variance (anovas), logistic regression, Cox
- model;
- to select genes that explain a response variable by applying multiple testing approaches;
- to analyse a data set of differential gene expression.

MOLECULAR AND CELLULAR IMAGING (MICROSCOPY)

Responsible lecturer: Arnaud Seigneurin

ECTS: 6

Course type and working hours: 50h

Exam type: t.b.d.

Lectures

Optical Microscopy:

- Basics of light microscopy, Köhler illumination, Contrast generation for transmitted light (Dark field, Polarized light, Phase contrast, DIC...)
- Fluorescence Microscopy, F-techniques, Optical Sectioning and Confocal Microscopy (Laser scanning confocal, multiphoton microscopy...)
- Processing and analysis of biological images

Electron Microscopy:

- Ultrastructural studies of the architecture of cellular components, viruses and macromolecular assemblies by electron microscopy (Transmission Electron Microscopy, Scanning, Cryo-EM...)
- Sample preparation, Image analysis

Discovering of X-Ray and near-field microscopies

Lab sessions:

- Optical Microscopy: Köhler illumination, Contrasts for transmitted light, Fluorescence microscopy, Image Processing

- Visits on research platforms allow the students to become familiar with modern microscopy techniques (laser scanning multiphoton, super resolution, F-techniques, imaging methods in electron microscopy ...).

Learning outcomes

- Acquisition by the students of autonomy on wide field optical microscopes,
- Thorough knowledge of the principles of electron microscopes
- Discovery of X-rays and near field microscopies.
- Practice of processing and analysis of biological images with open source software.

DATA ANALYSIS, LINEAR MODELS AND ANOVA

Responsible lecturer: Jean-Baptiste Durand, Clementine Prieur

ECTS: 6

Course type and working hours: 54h

Exam type: t.b.d.

Description

The aim of this course is to present advanced statistics and linear modelling, variance analysis and provide practical implementation

Contents

- Principal components analysis (PCA)
- Classification (Linear Discr. Analysis)
- Data mining (text mining)
- Linear regression
- Estimation and test of regression parameters
- ANOVA
- ANCOVA
- Practical implementation

This is a two parts course, including practical sessions:

1. 3 ECTS = Lecture 13h + Practical 5h + Lab 15h. Course mutualized with Ensimag 2A 4MMFDASM (head: Jean-Baptiste Durand)
2. 3 ECTS = Lecture 14h + Lab 6h - MSIAM specific course (in-depth and practical session) (head: Clémentine Prieur)

A short description of the course content can be found [here](#)

Prerequisites

Elementary notions in probability theory (probability distribution, joint probability density function for random vectors, conditional distribution, expectation, variance, covariance, Gaussian distribution)

Elementary notions in mathematical statistics (estimator, confidence interval, statistical tests). As a bonus: simple linear regression.

Notions in linear algebra (matrix reductions). As a bonus: elementary notions in Rstudio and the R software.

COMPUTING SCIENCE FOR BIG DATA AND HPC

Responsible lecturer: Clementine Prieur

ECTS: 6

Course type and working hours: 54h

Exam type: t.b.d.

Description

The aim of this course is to give an introduction to numerical and computing problematics of large dimension problems.

Contents

- Introduction to database
- Introduction to big data
- Introduction to high performance computing (HPC)
- Numerical solvers for HPC

Prerequisite

First semester of M1 MSIAM.

Learning outcome

Algorithmics of big data and HPC

NUMERICAL OPTIMISATION

Responsible lecturer: Laurent Desbat

ECTS: 6

Course type and working hours: 54h

Exam type: t.b.d.

Description

This program combines case studies coming from real life problems or models and lectures providing the mathematical and numerical backgrounds.

Contents

- Introduction, classification, examples.
- Theoretical results: convexity and compactity, optimality conditions, KT theorem
- Algorithmic for unconstrained optimisation (descent, line search, (quasi) Newton)
- Algorithms for non differentiable problems
- Algorithms for constrained optimisation: penalisation, SQP methods
- Applications

Prerequisite

linear algebra, differential calculus

Learning outcomes

- Recognise and classify optimisation problems
- Solve optimisation problems using adequate algorithms and methods
- Practical implementation

ADVANCED BIOSTATISTICS AND EXPLOITATION OF RESEARCH WORK

Responsible lecturer: Jean-luc Bosson

ECTS: 6

Course type and working hours: 44h

Exam type: t.b.d.

Parametric tests (Correlation - Regression, ANOVA, censored data analysis, PCA ...) and nonparametric tests (small sample cases) are discussed, up to complex multivariate models. The R - Rstudio software tool is used for the application examples.

There are 11 face-to-face sessions of SEPI or TD with 1 collaborative assignment (2 or 3 max) to be produced before the final MCQ-based exam. These assignments will be structured as statistical analysis protocols, preliminary stage of a scientific article and associated with a synthesis of multimedia presentation of the realized works.

1.3 2nd year, 1st semester (autumn/winter semester)

Innovation and Entrepreneurship 3 (9 ECTS)

THE HMDA'S SCHOOL ON LEARNING FROM HEALTH DATA

This summer school is offered and held by UGA for all HMDA students, which includes the preparation, execution and documentation of a practical project, which is based on a real use case in the healthcare context. For more information, please visit page 25.

ENTREPRENEURSHIP AND INNOVATION

Responsible lecturer: Daniel Bernard

ECTS: 3

Course type and working hours: 39h

Exam type: t.b.d.

Objective and learning outcomes

The aim of this course is to:

- Understand the main concepts related to technology ventures management.
- Understand and apply the main tools for business model generation.
- Develop the ability to search, analyse and combine business and technology information to build a business plan.

Learning outcomes

During this course, students will:

- Know the concepts and tools associated with technology management
- Know and apply the tools to generate business models from the analysis of the current state of technology
- Be able to work out a business plan

Content

1. Introduction to entrepreneurship: main concepts about technology new ventures. Main Founders' characteristics.
2. Establishing the business idea: Technology search and analysis.
3. Customer analysis: Market segmentation; End user analysis; Total Addressable Market (TAM) analysis.
4. Value proposition: Full Life Cycle; Product specification; Quantifying the value proposition.; Competitive analysis.
5. Product acquisition: understanding customers' decision process.
6. Business model generation: Business model canvas; Components' analysis; Design the business model; Lifetime Value of a customer; Cost of a Customer Acquisition.
7. Product design: defining the Minimum Viable Business Product.
8. Scaling the business & Building up the company: Technology venture financing; Negotiating deals; Company registration.

ENTREPRENEURIAL PROCESS & TOOLS

Responsible lecturer: Caroline Tarillon

ECTS: 6

Course type and working hours: 90h

Exam type: t.b.d.

Objective and learning outcomes

The aim of this course, is to:

- Analyse the functions developed by a biomedical engineer within an organization.
- Understand managerial concepts in a business environment.

Learning outcomes:

During this course, students will:

- Develop the ability to search, analyse and combine business information for decision making.
- Understand management of the main functional areas of a company: marketing, operations, finance, human resources and R&D.

Content

1. Strategic management: Management Strategy; Business values and orientation; External analysis; Internal analysis; Corporate, Business and Functional strategies
2. Marketing: Strategic marketing; Operative marketing: Four P's
3. Operations Management: Definition & Evolution; Strategies; Supply chain; Quality management; Five P's (product, process, plan, programme and people)
4. Human Resources: Planning; Recruiting; Selection; Training; Performance appraisal; Compensation
5. Innovation management (R&D): Sources; Innovation types ; Disruptive innovation ; Managing innovation
6. Finance: General concepts on financial cycles; Main financial documents; Cost Accounting.

RESEARCH AND DEVELOPMENT PROJECTS

Responsible lecturer: Jean Breton

ECTS: 3

Course type and working hours: 70h

Exam type: t.b.d.

Objective and learning outcomes

The aim of this course is to learn students how to apply the scientific method in the development of research and development projects, as well as in the dissemination of project results.:

Learning outcomes

During this course, students will:

- Work on bibliographical subject and make a critical discussion about the results in oral and public presentation.
- Perform an individual and a teamwork, developing the ability to search information sources, analyse the legislation for the collaboration of public and private entities, and apply methods for management of research projects.

BIOMEDICINES INNOVATIVE PROJECT

Responsible lecturer: Jean Breton

ECTS: 6

Course type and working hours: 30h

Exam type: t.b.d.

Content

This course takes a very practical, applied approach to the challenges of successful project management.

The essentials cover the following: structuring projects to set realistic goals and identify milestones; using effective tools for scheduling and be able to run single or parallel projects; identify project risks ; manage time, cost and quality; implement control systems to keep on top of the project.

Target

The Biomedicines innovative project has a wide range of possible applications for any initiative whose completion is fixed within specific time limits.

COMPUTATIONAL MEDICINE SUMMER SCHOOL

[COPD and Chronic conditions as Case Study]

Responsible lecturer: Philippe Sabatier

ECTS: 6

Course type and working hours: 85h

Exam type: t.b.d.

Objective and learning outcomes

CompMed is a Summer School, which expose participants to some of the latest biomedical advances. Students are invited to discover how engineering and computing solutions could be used to promote healthy living and active aging. The participants can leave a transformational experience, which will help them to develop transferable skills necessary for successful innovation. During the school, the students meet innovative scientist and high-tech start-up companies, and can discuss their ideas with highly qualified professors and young entrepreneurs. They are introduced to Creative Thinking, will have a unique opportunity to promote (pitch) their ideas in front of a medical/business panel, with the opportunity for further development of promising teams, and potential links to Health Accelerator.

Learning outcomes

By taking this course participants will:

- Know the definition of biological/pathological process; chronic disease; electronic health records; semantic data, mathematical modelling; Investigate biological/pathological process;
- Learn how design theoretical models; integrate multi-scale modelling; support interaction between deterministic model and probabilistic models; study perturbations of a biological process; explore the toolbox of biomathematics modelling.
- Study data representation and integration; explore semantic technologies and translational medicine; assess data warehouse solutions in terms of their targeted medical use case : data sharing, data interoperability and knowledge discovery.
- Discover and manage databases; Use specific and publicly available datasets (BioBridge and PAC-COPD); Create semantic mapping on inference engineering; Analyze associations of co-morbidities in PAC_COPD and in the Medicare database (diseasome)
- Integrate oxygen transport models from atmosphere to cell with mitochondrial reactive oxygen species (ROS) generation and metabolic pathways.
- Provide intuitive users interfaces for clinician and bio-researchers.

Content

CompMed learn clinicians, scientists, and engineers in computational medicine and healthcare optimization for chronic diseases (CD) focused on COPD as case study. CompMed aims to use a system approach for the study of the underlying mechanisms of diseases' phenotypes associated with poor prognosis. To address this tricky challenge, CompMed propose a dynamic approach, based on complex problem solving. COPD is caused by unhealthy lifestyles and increased life expectancy, complex gene environment interactions, intrinsic host responses, such as local and systemic inflammation, epigenetic changes and decoupling of basic regulatory mechanisms with impact on bioenergetics, metabolome, proteome, genome, microbiome, immune responses and remodeling. Through the case study on COPD, participants are invited to work, step by step, on a better understanding of the physio-pathological mechanisms explaining co-morbidity, which seems to be crucial not only for a better diagnosis and treatment, but also to envision new formats of service delivery considering early patient stratification based on characterization of disease phenotypes. The learning process is based on the iterative loop of Systems Medicine approach:

1. Formulate and formalize a question
2. Define, Integrate and Perturb systematically the system components
3. Check model predictions; Collect appropriate data sets (targeted and global); Compare the
4. observed/predicted results;
5. Refine the model so that its predictions fit better with the experimental observations; Iterate the
6. process until an answer to the initial question is obtained.

The program culminates in a capstone design-project in which students work in interdisciplinary teams co-advised by faculty members and investigators from industries and hospitals. The participants are introduced to Creative Thinking, and throughout the last day, they present (pitch) their projects in front of a business/medical panel, who will join the session and provide their valuable feedback. CompMed provides participants with a broad but high-level scientific background and important skills such as conceptual approaches, teamwork, management of complex processes, entrepreneurship and high intercultural awareness. The school combines an intensive program of lectures, hands-on sessions (experiments, simulation and modeling) and group working.

Courses are given by teachers from France, Spain, United States, Sweden, Germany, the Netherlands, Great-Britain and Switzerland.

HMDA specialization (21 ECTS)

MOLECULAR TOOLS FOR THE DIAGNOSIS AND TREATMENT OF GENETIC DISEASES

Responsible lecturer: Jean Breton

ECTS: 3

Course type and working hours: 29h

Exam type: t.b.d.

Course module description

This course will cover the principles of Molecular Diagnosis which is the process of identifying a disease by studying molecules, such as proteins, DNA, and RNA, in a tissue or fluid. Molecular diagnostics is a new discipline that captures genomic and proteomic expression patterns and uses the information to distinguish between two or more conditions at the molecular level. The conditions under investigation can be human genetic disease or infectious diseases. Molecular diagnostics is not confined to human diseases but can be also used in environmental monitoring, food processing ...etc.

Many of the diagnostic techniques are developed and marketed in kit format by biotechnology companies. The main source of information is web sites of companies that develop and market the molecular diagnostic kits. New methods are continuously developed. The objective of this course is learning and understanding how molecular techniques that were studied in other classes can be developed and utilized in diagnosis and sold in diagnostic kits.

Intended learning outcomes

- Knowledge and understanding of the basic principles used in molecular diagnosis.
- Gain thinking and analysis skills to understand new diagnostic methods
- Ability to collect information to develop a new diagnostic kit.
- Knowledge and skills gained in the course should be useful in practical life in developing or using diagnostic kits

MOLECULAR MARKERS FOR MEDICAL IMAGING

Responsible lecturer: Franz Bruckert

ECTS: 3

Course type and working hours: 30h

Exam type: Written report based on articles proposed by the lecturers written report

Goals

Series of seminars on the development and use of contrast agents and molecular markers in biomedical imaging and therapy

Content

Contrast agents and molecular markers for ultrasound, X-Ray and MRI imaging
Development and use of visible and infrared fluorophores
Application to cardiovascular diseases, cancer and neurodegenerative diseases.

Prerequisites

Molecular biology and physiology courses

NUMERICAL SIMULATIONS AND STATISTICAL DATA ANALYSIS

Responsible lecturer: Judith Peters

ECTS: 3

Course type and working hours: 30h

Exam type: Written exam (2h)

Content

The course will deal with the uncertainties of the experimental data, including the notions of probability, the random variable and distributions. Some hypothesis tests and confidence intervals will be presented. Simulation methods such as the Monte Carlo method will be introduced. The acquired techniques will be applied to selected examples in the field of life sciences and the environment.

MODELLING IN SYSTEMS BIOLOGY

Responsible lecturer: Delphine Ropers

ECTS: 3

Course type and working hours: 30h

Exam type: only in English, continuous evaluation with homework assignment

Goals

The course provides an introduction to systems biology by focusing on the behaviors emerging from interactions between genes, proteins and RNAs, taking examples from microbes to mammals. The main goal of this course is to show students that abstract computational and mathematical methods can be effectively employed for in silico modeling and analysis of living organisms. Moreover, to enhance practical skills, students will apply some of the techniques and software tools to analyze genome-scale models and models of cell metabolism and gene expression.

Content

The different steps of the model development will be presented: initial observations, hypotheses, model testing and validation. Different types of models will be described and illustrated, for instance: deterministic versus stochastic, static versus dynamic or versus non-parametric, lumped versus distributed. These notions will be illustrated by mathematical models in the biomedical field as for instance physiological models (Hodgkin-Huxley), compartment models or population models.

- Introduction to cellular networks and mathematical modelling (course: 2h)
- Mathematical modelling of cell metabolism: flux balance analysis (course: 2 hours + 2 hours computer lab exercises)
- Kinetic models of integrated networks and introduction to other modelling frameworks (4 hours + 2 hours computer lab exercises)
- Identification and inference of metabolic network models (2 hours + 2 hours computer lab exercises)

Intended Learning Outcomes

- Understand basic knowledge about biological systems in order to model them.
- Understand and be able to model different types of biological systems by using appropriate modelling tools.
- Choose appropriate models and argue about these choices depending on the modelling application.
- Make a critical analysis about the relevance and interest of mathematical models of biological systems in their capacity to predict new experimental results and inspire original experimental protocols.
- Use softwares and computers to implement and simulate mathematical models of biological systems.

Learning outcomes

- Make a critical analysis of the scientific literature devoted to the development of original mathematical models of biological systems.
- Make a concise and critical presentation of a scientific article related to mathematical models of biological systems.

ADVANCED ALGORITHMS FOR MACHINE LEARNING AND DATA MINING

Responsible lecturer: Eric Gaussier

ECTS: 3

Course type and working hours: 18h

Exam type: t.b.d.

Description

- A prior algorithm (Frequent item sets) & Page Rank
- Monte-carlo, MCMC methods: Metropolis-Hastings and Gibbs Sampling
- Matrix Factorization (Stochastic Gradient Descent, SVD)
- Generalized kmeans and its variants (Bach, Online, large scale), Kernel clustering (Support Vector Clustering), Spectral clustering
- Classification and Regression Trees, Support Vector regression
- Alignment and matching algorithms (local/global, pairwise/multiple), dynamic programming, Hungarian algorithm,...

Prerequisite

Fundamentals of probability/statistics, linear algebra and computer science (data structures and algorithms)

Bibliography

C.D. Manning, P. Raghavan and H. Schütze. « **Introduction to Information » Retrieval**. Cambridge University Press, USA, 2008.

A. DasGupta. « **Probability for Statistics and Machine Learning** ». Springer, 2011.

I. Goodfellow, Y. Bengio, A. Courville. « **Deep Learning** ». MIT Press, 2016.

C.M. Bishop. « **Pattern Recognition and Machine Learning** ». Springer Verlag, 2006.

ADVANCED LEARNING MODELS

Responsible lecturer: Julien Mairal

ECTS: 3

Course type and working hours: 18h

Exam type: written homework with theoretical exercise, participation in a data challenge

Description

Statistical learning is about the construction and study of systems that can automatically learn from data. With the emergence of massive datasets commonly encountered today, the need for powerful machine learning is of acute importance. Examples of successful applications include effective web search, anti-spam software, computer vision, robotics, practical speech recognition, and a deeper understanding of the human genome.

This course gives an introduction to this exciting field, with a strong focus on kernels methods and neural network models as a versatile tools to represent data

This course deals with:

Topic 1: Neural networks

- Basic multi-layer networks
- Convolutional networks for image data
- Recurrent networks for sequence data
- Generative neural network models

Topic 2: Kernel methods

- Theory of RKHS and kernels
- Supervised learning with kernels
- Unsupervised learning with kernels
- Kernels for structured data
- Kernels for generative models

Prerequisites

Fundamental notions in linear algebra and statistics.

Basic programming skills to implement a machine method of choice encountered in the course from scratch →

<http://thoth.inrialpes.fr/people/mairal/teaching/2017-2018/MSIAM>

BAYESIAN STATISTICS

Responsible lecturer: Julyan Arbel

ECTS: 3

Course type and working hours: 18h

Exam type: t.b.d.

Objectives

The course aims at providing an overview of Bayesian parametric and nonparametric statistics. Students will learn how to model statistical and machine learning problems from a Bayesian perspective and study theoretical properties of the models.

Syllabus

This course is in two parts covering fundamentals of Bayesian parametric and nonparametric inference, respectively. It focuses on the key probabilistic concepts and stochastic modelling tools at the basis of the most recent advances in the field.

Part 1

- Foundations of Bayesian inference: exchangeability, de Finetti's representation theorem
- Conjugacy in simple models (binomial, Poisson, Gaussian)
- Some elements of posterior sampling, Markov chain Monte Carlo
- Bayesian neural networks and their Gaussian process limit

Part 2

- Clustering and Dirichlet process, random partitions
- Models beyond the Dirichlet process, random measures, Indian buffet process
- Some elements of Bayesian asymptotics

Bibliography

- Hoff, P. D. (2009). A first course in Bayesian statistical methods. Springer Science & Business Media.
- Neal, R. M. (2012). Bayesian learning for neural networks (Vol. 118). Springer Science & Business Media.

- Hjort, N. L., Holmes, C., Müller, P., & Walker, S. G. (2010). Bayesian nonparametrics. Cambridge series in statistical and probabilistic mathematics. Cambridge: Cambridge Univ. Press.
- Orbanz, P. (2012). Lecture Notes on Bayesian Nonparametrics
- Kleijn, B., van der Vaart, A., & van Zanten, H. (2012). Lectures on Nonparametric Bayesian Statistics.

CATEGORY LEARNING AND OBJECT RECOGNITION

Responsible lecturer: Jakob Verbeek

ECTS: 3

Course type and working hours: 18h

Exam type: t.b.d.

Description :

In this course we present recent state-of-the-art methods for visual object category representation and recognition, and the techniques that underpin these methods. Methods will include so called "bag of features" approaches, Fisher vectors, and convolutional neural networks for tasks such as instance-level image retrieval, image classification, object localization, semantic segmentation, image caption generation and action recognition in videos. On the machine learning side we consider clustering methods (k-means, mixture of Gaussians), classification techniques (SVM, logistic discriminant), and kernels to obtain non-linear classifiers, as well as the principles underlying neural networks (multi-layer perceptron, back-propagation, convolutional networks, recurrent networks).

COMPUTATIONAL BIOLOGY

Responsible lecturer: Olivier François, Michaël Blum

ECTS: 3

Course type and working hours: 18h

Exam type: oral presentation, written exam

Description:

This interdisciplinary MSc course is designed for applicants with a biomedical, computational or mathematical background. It provides students with the necessary skills to produce effective research in bioinformatics and computational biology. The objective of the course is to introduce mathematical biology questions, stochastic and deterministic approaches for modeling biological systems, and advanced tools for the analysis of biological data.

The topics addressed in this course include a brief introduction to stochastic processes and differential equations and their application to biological problems. The first part of the course focuses on modelling in molecular biology and evolution, and on the analysis of molecular phylogenetic or population genetic data. The second part of the course focuses on models in cellular biology and biomechanics.

Prerequisites:

No specific prerequisites.

MACHINE LEARNING FUNDAMENTALS

Responsible lecturer: Massih-Reza Amini, Marianne Clausel

ECTS: 3

Course type and working hours: 30h

Exam type: Homeworks (30%), final exam (70%)

Description

- Consistency of the Empirical Risk Minimization
- Uniform Generalization Bounds and Structural Risk Minimization
- Unconstrained Convex Optimization
- Binary Classification algorithms (Perceptron, Adaboost, Logistic Regression, SVM) and their link with the ERM and the SRM principles
- Multiclass classification
- Application and experimentations

Prerequisites

Statistics and probability (BSc)

Learning outcomes

Understanding of fundamental notions in Machine Learning (inference, ERM and SRM principles, generalization bounds, classical learning models, unsupervised learning, semi-supervised learning).

Bibliography

- Massih-Reza Amini - [Apprentissage Machine de la théorie à la pratique](#), Eyrolles, 2015.
- Christopher Bishop - [Neural Networks for Pattern Recognition](#), Oxford University Press, 1995.
- Richard Duda, Peter Hart & David Strok - [Pattern Classification](#), John Wiley & Sons, 1997.
- John Shawe-Taylor & Nello Cristianini - [Kernel Methods for Pattern Analysis](#), Cambridge University Press, 2004.
- Colin McDiarmid - [On the method of bounded differences](#), Surveys in Combinatorics, 141:148-188, 1989.
- Mehryar Mohri, Afshin Rostamzadeh & Ameet Talwalker - [Foundations of Machine Learning](#), MIT Press, 2012.
- Bernhard Schölkopf & Alexander J. Smola - [Learning with Kernels](#), MIT Press, 2002.
- Vladimir Kolchinskii - [Rademacher penalties and structural risk minimization](#), IEEE Transactions on Information Theory, 47(5):1902–1914, 2001.

FUNDAMENTALS OF PROBABILISTIC DATA MINING

Responsible lecturer: Jean-Baptiste Durand

ECTS: 3

Course type and working hours: 30h

Exam type: written exam (2h), 2 reports

Description:

This lecture introduces fundamental concepts and associated numerical methods in model-based clustering, classification and models with latent structure. These approaches are particularly relevant to model random vectors, sequences or graphs, to account for data heterogeneity, and to present general principles in statistical modelling. The following topics are addressed:

- Principles of probabilistic data mining and generative models; models with latent variables
- Probabilistic graphical models
- Mixture models and clustering
- PCA and probabilistic PCA
- Nonparametric density estimation
- Generative models for series and graphs: hidden Markov models

Prerequisites:

Fundamental principles in probability theory (conditioning) and statistics (maximum likelihood estimator and its usual asymptotic properties). Constrained optimization, Lagrange multipliers.

Learning outcomes:

At the end of the course, the student will be able to perform model-based clustering, analysis and segmentation of time-series with hidden Markov models, build a graphical model associated with a given distribution and represent numerical multivariate data with missing coordinates into planes.

Bibliography :

Lauritzen, S.L. Graphical Models. Clarendon Press, Oxford, United Kingdom, 1996.

Koller, D. and Friedman, N. Probabilistic graphical models: principles and techniques. MIT press, 2009.

Bishop, Christopher M. Pattern Recognition and Machine Learning. Springer Verlag, 2006.

MODEL SELECTION FOR LARGE-SCALE LEARNING

Responsible lecturer: Emilie Devijver

ECTS: 3

Course type and working hours: 60h

Exam type: t.b.d.

Description

When estimating parameters in a statistical model, sharp calibration is important to get optimal performances. In this course, we will focus on the selection of estimators with respect to the data. Particularly, we will consider calibration of parameters (e.g., regularization parameter for minimization of regularized empirical risk, like Lasso or Ridge estimators) and model selection (where each estimator minimizes the empirical risk on a specified model, as mixture models with several number of clusters).

We will focus on the penalized empirical risk, where the penalty may be deterministic (as BIC or ICL) or estimated with data (as the slope heuristic).

Prerequisites :

Basic knowledges in probability and statistics

Target skills :

Learn

- When model selection is needed.
- What can be proved theoretically for existing methods.
- How those results can help in practice to choose a criterion for some specific statistical problem
- How the theory can serve to define new procedures of selection.

References:

T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning. Data Mining, Inference, and Prediction

P. Buhlmann and S. van de Geer, Statistics for High-Dimensional Data. Methods, Theory and Applications

P. Massart, Concentration Inequalities and Model Selection

INFORMATION VISUALIZATION

Responsible lecturer: Renaud Blanch

ECTS: 3

Course type and working hours: 18h

Exam type: t.b.d.

Description

Interactive Information Visualization (InfoVis) is the study of interactive graphical representations of abstract data (e.g. graphs linking people in social networks, series of stock-options values evolving over time).

Graphical representations are a powerful way to leverage the human perceptual capabilities to allow the user to explore and make sense of abstract data, and also to expose findings and convey ideas.

But to be efficient, a visualization has to be designed using knowledge about the human visual perception, the characteristics of the data, the kind of task that will be performed on those data.

The aim of this course is to provide the keys, both theoretical and practical, to build usable and useful interactive visualizations.

Program summary:

- foundations: human visual perception, graphical variables, data types, the visualization pipeline.
- linked data: tree and graph visualization
- tabular data: time series and spatial data visualization
- dealing with large data: aggregation, multiple views, interaction
- validating visualization: visualization tasks, evaluation

DATA CHALLENGES

Responsible lecturer: Jean-Baptiste Durand

ECTS: 3

Course type and working hours: 60h

Exam type: report (1/3), oral presentation (1/3), score (1/3)

Description

Face up challenging real-world problems in machine learning, be involved in multidisciplinary teams of data scientists, computer scientists, mathematicians and expert students in signal processing, and contribute to leading your team to the top rank!

Different teams with M2 students issued from either [MSIAM Data Science](#), [MoSIG Data Science](#) and [SIGMA](#) work on a same challenge on either complex, structured or big data, and maybe a combination of all three. Try and compare different approaches, take benefit from the computational power of clusters and from advice of your supervisors.

The data challenges stretch on several months, include some tutored sessions, if needed mini-courses, and of course your regular involvement over that period of time.

Prerequisites

Elementary notions in probability theory (multivariate distributions), machine learning (concepts of regression, classification and clustering) and programming (usually python, although other languages may be chosen).

Learning outcomes

At the end of the course, the student will be able to work in teams involving various skills (machine learning, statistical modelling, programming, data bases and others). They will acquire skills in data analysis and self-training in acquiring or reinforcing skills among the four listed above.

Bibliography

Dopplick, R. [Expanding minds to big data and data sciences](#). *Inroads*, 6(3) 88, 2015.

Yang, J. [How we did it: Jie and Neeral on winning the first Kaggle-in-class competition at Stanford](#), 2010.

[Organization of the data challenge in 2018-2019](#)

[Detailed description of GBX9AM20](#) ; [MSIAM Course list](#) ; [Semester 3 \(MSIAM tracks\)](#)

DATA MANAGEMENT IN LARGE-SCALE DISTRIBUTED SYSTEMS

Responsible lecturer: Thomas Ropars

ECTS: 3

Course type and working hours: 18h

Exam type: written exam, practical work

Description

Target skills : Data management and knowledge extraction have become the core activities of most organizations. The increasing speed at which systems and users generate data has led to many interesting challenges, both in the industry and in the research community.

The data management infrastructure is growing fast, leading to the creation of large data centers and federations of data centers. These can no longer be handled exclusively with classic DBMS. It requires a variety of flexible data models (relational, NoSQL...), consistency semantics and algorithms issued by the database and distributed system communities. In addition, large-scale systems are more prone to failures, and should implement appropriate fault tolerance mechanisms.

The dissemination of an increasing amount of sensors and devices in our environment highly contribute to the "Big Data" and the development of ubiquitous information systems. Data is processed in continuous streams providing information related of users context, such as their movement patterns and their surroundings. This data can be used to improve the context awareness of mobile applications and directly target the needs of the users without requiring an explicit query.

Combining large amounts of data from different sources offers many opportunities in the domains of data mining and knowledge discovery. Heterogeneous data, once reconciled, can be used to produce new information to adapt to the behavior of users and their context, thus generating a richer and more diverse experience. As more data becomes available, innovative data analysis algorithms are conceived to provide new services, focusing on two key aspects: accuracy and scalability.

Program summary : In this course, we will study the fundamentals and research trends of distributed data management, including distributed query evaluation, consistency models and data integration. We will give an overview of large-scale data management systems, peer-to-peer approaches, MapReduce frameworks and NoSQL systems. Ubiquitous data management and crowdsourcing will also be discussed.

Prerequisites

Fundamentals of DBMS, parallel programming (threads)

Learning outcomes

At the end of the course, the students will know how to use Big Data software tools to efficiently store and process large amounts of data, including tools that can operate in realtime.

Bibliography

- Dean, Jeffrey, and Sanjay Ghemawat. "MapReduce: simplified data processing on large clusters." *Communications of the ACM* 51.1 (2008): 107-113.

- Zaharia, Matei, et al. "Apache spark: a unified engine for big data processing." Communications of the ACM 59.11 (2016): 56-65.
- Murray, Derek G., et al. "Naiad: a timely dataflow system." Proceedings of the Twenty-Fourth ACM Symposium on Operating Systems Principles. ACM, 2013.
- Lakshman, Avinash, and Prashant Malik. "Cassandra: a decentralized structured storage system." ACM SIGOPS Operating Systems Review 44.2 (2010): 35-40.

DATA SCIENCE SEMINAR

Responsible lecturer: Jean-Baptiste Durand, Ronald Phlypo, Olivier Michel

ECTS: 3

Course type and working hours: seminar

Exam type: oral exam

Description

Our master programs now include a series of 6 or 7 seminars given by active researchers in the field of data processing methods and analysis.

These seminars are intended to give students some insights on modern problems and solutions developed in a data science framework, with applications in a variety of fields.

In order to make these seminars a most valuable experience for all students, a scientific paper dealing with the topic of the seminar will be selected by the speaker and dispatched to all students about 2 weeks before the seminar. Students are expected to read and study this paper, and to prepare questions, before attending the seminar. Presence at the seminars is compulsory for master students.

At the end of the seminar series, some oral exam is organized. One of the topic presented during the seminars is randomly assigned to each student a few days in advance. The oral exam consists in a 25 min summarized presentation of the scientific issues that were addressed, and a 15 min session of discussion and questions. A second different topic is chosen by the student, and he/she must write a report on that topic, based on the seminar and associated articles.

SOFTWARE DEVELOPMENT TOOLS AND METHODS

Responsible lecturer: Mourad Ismail

ECTS: 3

Course type and working hours: seminar, 39h

Exam type: practical session reports, oral presentation

Description

The aim of this course is to study various useful applications, libraries and methods for software engineering related to applied mathematics. For example :

- C++ project management (git and/or svn)
- Development and profiling
- Boost library
- Linear algebra (Eigen)
- Prototyping and interfacing using Python
- Post processing and visualization tools (VTK, Paraview, GMSH)

This course deals with :

Topic 1: Software Engineering

Topic 2: Programming

Prerequisite

Linear algebra: fundamental notions (matrices, linear functions), Programming in C++ and python

Learning outcomes

At the end of the course, students will be able to manage and couple different libraries, to debug correctly a code (find memory leaks for example).

1.4 2nd year, 2nd semester (spring/summer semester)

Master's thesis in collaboration with industry partner or hospital

30 ECTS

Objective and learning outcomes

- The master thesis in Biomedical Engineering is typically a research project or study, or an extended analysis of a topic of scientific or technological nature. The goal is for students to perform research and apply the knowledge acquired during their studies while at the same time developing skills like initiative, autonomy skills, decision and organization.
- The main learning output of this master thesis is the students' ability to work on a BME program, and to translate research into applications – in cooperation with a non-academic business partner. This innovative approach is based on the mobility of students, exchanging experiences in different disciplines and establishing a common high-quality standard in education and training.
- At the end of the master thesis students work should reflect the EIT OLOs 1-6.

Content

The program is defined according to the supervisor orientation and to the type of theme and it is developed during one of the semesters of the last year of the MSc Course. Following the MSc procedures, the Education Committees has assessed the scientific quality and feasibility of the master thesis proposals. It is anticipated that the thesis will be relevant to the student's track and will address a question of importance in the student's field of expertise. Students are expected to design a research project, write a formal research protocol, perform the study described in it, and prepare a comprehensive scholarly scientific paper reporting the results. Optionally, part of the master project could be done at another institute or company outside Partner Universities, but in this case, it is always under supervision of a Partner University staff member. To achieve their research project, students are required to write a scientific paper under guidance of their research supervisors, and to give a presentation about the research performed. The scientific paper must be approved by the academic supervisor and be suitable for submission to an international, scientific journal. The thesis can take place at universities, research centers or companies. As mentioned above, the thesis requires an advisor from the Engineering side and a co-advisor from a non-academic partner.

SUMMER SCHOOL ARTIFICIAL INTELLIGENCE FOR HEALTH

6 ECTS, Philippe SABATIER philippe.sabatier@univ-grenoble-alpes.fr

Objective and learning outcomes

AI4Health's mission is to teach advanced topics related to Big Data computing and analytics for health and wellbeing, as well as to enhance innovation and entrepreneurial awareness amongst participants. The participants can leave a transformational experience, which will help them to develop transferable skills necessary for successful innovation. During the school, the students meet innovative scientist and high-tech start-up companies, and can discuss their ideas with highly qualified professors and young entrepreneurs. They are introduced to Creative Thinking, will have a unique opportunity to promote (pitch) their ideas in front of a medical/business panel, with the opportunity for further development of promising teams, and potential links to Health Accelerator. IBD4Health is part of the bioHC program which educates since 2011 outstanding minds and cultivates future leaders who will explore fundamental principles underlying disease and design new biomedical technologies for health and wellbeing.

Outcomes

By taking this course participants will:

- Know definition Big Data: (volume, velocity, variety, value), challenges. Study how and where Big Data challenges arise in a number of domains (including medicine, social media, insurance and finance). Investigate web challenges and how to engineer around them. Discover user interfaces for Big Data and their functions.
- Learn how designing theoretical models to investigate biological and pathological process of Chronic Diseases. Use the toolbox of biomathematics modelling.
- Work on data representation and integration, in particular with semantic web technologies and data sharing, data interoperability and knowledge discovery. Explore the SQL & NoSQL systems, their capabilities and pitfalls, and how the NewSQL movement addresses these issues in terms of scalability, performance, and robustness.
- Explore data representation and integration, in particular with semantic web technologies and translational medicine. Assess existing solutions in terms of their target medical use case and of data sharing, data interoperability and knowledge discovery.
- Analyse Big Data: statistical learning and evidence-based medicine.
- Propose technology transfer in healthcare, and population wellbeing. Study the ethical issues and discover recent techniques that help building secure Big Data systems; resolving the challenges of sharing protected data and of integrating semantic-driven technologies into the clinical practice.
- Solve the obesity study case by team working; Writing and defending orally an executive summary.

Content

IBD4Health focuses on the technology, unmet needs, business, value chain, privacy and security aspects of future Health Clouds. Data collection on a large scale could provide materials for in-depth analysis of different causal and contributory factors, supporting the development of effective interventions and public health approaches to tackle obesity. IBD4Health comprises interactive morning sessions, including guest presentations, and computer practice on case study, and afternoon sessions focused on innovation and entrepreneurship, including workshops, group assignments, etc. The programme is organised in three sessions: 1st Session: Health, wellbeing and data challenges; 2nd Session: Data oriented design, collection, computing and analytics; 3rd Session: Innovation and entrepreneurship.

The School's program starts with an Introductory round table (session 1) and ends with a Pitching session and a Design Thinking Workshop (session 3). Everyday sessions mix a comprehensive range of practical tools and real-life experiences. Time off between the sessions allowed participants to work on individual or team projects.

Lectures & Practical Exercise on Data Design, Collection, Computing, Analytics, introduce the state-of-the-art on Big Data Technologies: from oriented design, collection, storage, computing, security and privacy and big data. Through the case study on obesity, multidisciplinary participants are invited to discover, step by step, the main sources of data and efforts to develop new tools on large-scale data processing application, which involves very complex systems and sophisticated mechanisms. Innovation & Entrepreneurship Session is devoted to working on innovative ideas and translating them into value creation through business model approach. At the end of the Opening Day, 5 Group Projects (GP) are selected from the Personal Projects (PP) proposed on the student's applications. Students are invited to explore the following aspects: unmet need, mobilized technology, developments to achieve, market analysis, etc. Participants are introduced to Creative Thinking as well as applied Design Thinking and Pitching. CERN BIC network proposes teaching based on the expertise of hosted SME and Spin-off. IBD4Health provides participants with a broad but high-level scientific background and important skills such as conceptual approaches, teamwork, management of complex processes, entrepreneurship and high intercultural awareness. The school combines an intensive programme of lectures, hands-on sessions (experiments, simulation and modelling) and group working. Courses are given by teachers from France, Spain, United States, Sweden, Germany, the Netherlands, Great-Britain and Switzerland.

SUMMER SCHOOL ON SAFER NANOMATERIALS

6 ECTS, Philippe SABATIER philippe.sabatier@univ-grenoble-alpes.fr

Objective and learning outcomes

SaferNano Design & Law (Safer Design for Nanomaterials) is a Summer School which focuses on advanced methods and innovative approaches to NTs' safety-by-design, in order to reduce the need of, and/or foster substitution of Critical Raw Materials (CRMs) in the main EU industrial Value Chains.

The three main objectives are:

- Educate students to become highly skilled European professionals with expertise in NT's EHS. This expertise will enable them to develop new methods for life cycle assessment and safer designing of nanomaterials.
- Enable participants to become leading practicing engineers, across all sectors of society including academia, industry and public service, with transferable skills such as innovation, ethics, intellectual property, sustainability and advanced research strategies.
- Develop a deep entrepreneurship mindset with the help and expertise of associated businesses, incubators and innovation services as well as a large panel of industries.

Outcomes

SaferNano Design & Law provides participants with a broad but high-level scientific background in the field, of nanosafety and important skills such as teamwork, management of complex processes, conceptual approaches, entrepreneurship and high intercultural awareness. Students are trained on how to get and analyse omics data to perform gene ontology and pathway analysis. They also become familiar with predictive toxicology via the Adverse Outcome Pathways (AOP) and Effectopedia tool. By taking this course participants will have gained:

- Broad view of the nanotechnology market and the evolving regulatory framework,
- Knowledge on theoretical and practical understanding of nanomaterial reactivity and transformation in the environment; and on the surface reactivity and on the 'nano-specific' properties useful for diverse applications.
- Knowledge on how to assess environmental impacts of nanomaterials using a life cycle assessment model, and to develop nanomaterials and nanoproducts using a safer by design approach.
- Insight on the different types of assays available to assess the impact of nanomaterial exposure at different levels (environment, organism, cell, molecule etc.
- Overview of nowadays and future nanotoxicology: the different types of assays available to assess the impact of nanomaterials exposure at the organism but also cellular and molecular levels. Finally, the students will have gained knowledge on how to assess the biological response to nanomaterial exposure.
- Mastery of the general legislation concerning eco-design at EU and national levels, as well as working knowledge of value chain issues and marketing. It also includes the capacity to analyse in specific contexts how innovative strategies may lead to improved firm performance or to new business perspectives.

Content

Nanotechnology is now bringing new opportunities to reduce the need of, and/or foster substitution of Critical Raw Materials in the main EU Industrial Value Chains. SaferNano Design & Law address the tricky challenge of the Nanotechnology's transition by promoting 'safety-by-design' that minimizes the risks associated to environment and population health. By working on case studies, participants learn the main computing tools and databases for addressing the life cycle of the products. Additionally, they are introduced to Creative Thinking & 1st Session Business Creation and invited to pitch their ideas in front of a business panel. The program is organized in four sessions: 1st session: Nanomaterials and their life-cycle analysis; 2nd Session: Nanomaterials transformation in the environment; Ecosystem and Human Exposure; 3rd Session: Human toxicity; 4th Session: Innovation, Technology transfer and Business development. The school combines an intensive program of lectures, hands-on sessions (experiments, simulation and modeling) and group working. Courses are given by teachers from France, Spain, United States, Sweden, Germany, the Netherlands, Great-Britain and Switzerland.