INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

FOURTH YEAR – MA

Practical info

Location(s)

Toulouse

Partial Derivative Equations & Monte Carlo methods

ECTS
4 crédits

Hourly volume
53h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
PDE
- The four fundamentals PDE models, with their solution behaviors
- The Finite Difference discretization method

Monte-Carlo
- The fundamental principles of simulating random variables and Monte-Carlo methods.

The student will be able to:
PDE
- To model basic fundamental phenomena by employing PDE
- To derive a Finite Difference scheme (consistent, stable, convergent).

Monte-Carlo
- Simulate a random variable by different methods, use probabilistic, choose appropriate techniques for variance reduction and error estimation.

Necessary prerequisites

EDP
Differential calculus, analysis, ODE

Basic numerical methods

Monte-Carlo
A basic course on probabilities.

Practical info

Location(s)

Toulouse

Advanced probability and Monte Carlo methods

ECTS
4 crédits

Hourly volume
53h

Introducing

Objectives

Objectives:
At the end of this module, the student will have understood and be able to explain (main concepts):
- The notion of conditional expectation, the main properties of martingales and their classical use in modelling,
- Stochastic algorithms of Robbins-Monro type.
- The fundamental principles of simulating random variables and Monte-Carlo methods.

The student will be able to:
- To compute a conditional expectation, to show that a random process is a martingale, to use the various theorems (Doob, optional stopping and convergences), in particular for the maximum likelihood estimation.

- Build and study the convergence of stochastic optimization algorithms, apply these methods to different problems (quantile, quantization,¿)

Simulate a random variable by different methods, use probabilistic, choose appropriate techniques for variance reduction and error estimation

Necessary prerequisites

Necessary knowledge:

A basic course on probabilities.

Practical info

Location(s)

Toulouse

Improve your management abilities

ECTS
4 crédits

Hourly volume
45h

Management I3CCGE51

Introducing

Objectives

At the end of this module, the student will

¿ Know the legal environment and responsibilities of a business
activity
¿ Be able to objectively assess the financial health of a company and evaluate the rentability of an investment
¿ Realize a market diagnosis (benchmarking) and a business diagnosis in order to make decisions and set goals and strategies
¿ Collect the market data and put in action a business plan adapted to the means and goals of the company
Module L 2
The objectives, defined in reference to the CEFRL for the 5 language activities, are specific for the language studied Chinese, German, Spanish ¿ and the level of the student.

They can be consulted on :

https://moodle.insa-toulouse.fr/course/view.php?id=44

In certain cases, students may be authorised to follow an English module instead of another language

Necessary prerequisites

Practical info

Location(s)

Toulouse

Toulouse School of Management

Practical info

Location(s)

Toulouse

Optimisation II

ECTS
4 crédits

Hourly volume
54h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Deterministic differentiable optimisation :
Existence and unicity of optimisation problems, KKT points, Convergence of optimization algorithm, Lagrangian duality

- Discrete stochastic optimisation :
The Metropolis-Hastings algorithm, the simulated annealing algorithm, genetic algorithms.

The student will be able:
- To identify families of optimization problems
- To choose and implement suitable first and second order algorithms
- To implement a Metropolis-Hastings algorithm in order to simulate, approximately, a given discrete probability distribution on a huge finite space.
- To implement a simulated annealing algorithm in order to minimize a given function on a huge finite space.

Necessary prerequisites

Optimisation I
Markov chains and applications

Practical info

Location(s)

Toulouse

Signal Processing 1

ECTS
4 crédits

Hourly volume
43h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

1) Signal and Image processing basic notions : sampling, windowing and sampling
2) FFT algorithm
3) Basis notions on Hilbert spaces and Hilbert bases

The student will be able to:

1) Use the FFT and understand the output on a Signal or an image.
2) Apply several transformations to a signal and an image using the FFT

Practical info

Location(s)

Toulouse

Statistical Modelling

ECTS
4 crédits

Hourly volume
53h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-The use of statistical tests for goodness-of-fit, independence, populations comparisons
-The characteristics of a linear model and a generalized linear model, and their use for statistical modelling

At the end of this module, the student should be able to:

-Choose a test procedure suited to a given problem
-Build nonparametric test procedures to compare two populations
-Build goodness-of-fit tests for a single distribution or a family of distributions
-Choose a linear model or a generalized linear model suited to a given problem
-Estimate the parameters in a linear model and a generalized linear model
-Use statistical tests to validate or invalidate hypotheses on these linear models and generalized linear models.
-Implement a variable selection strategy
-Perform a complete statistical analysis on a real data set using a linear model or a generalized linear model

Necessary prerequisites

Probability and Statistics (I2MIMT31)
Statistics (I3MIMT15)

Practical info

Location(s)

Toulouse

HPC, Matrix Computations and Large Sparse Systems

ECTS
4 crédits

Hourly volume
59h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
Eigenproblems :
- Different eigenproblems, their conditioning and Schur¿s factorization,
- Different methods for eigenvalue problems : power method, orthogonal iterations, QR method and Krylov subspace methods.

HPC :
This module is focused on the presentation of the basic mechanisms used to achieve high performance on modern computers. The language used by the students will be Python/C with which they¿ll learn to implement some MPI. They will also learn to program some Krylov¿s solvers as well as the LU factorization and to efficiently solve Poisson¿s equation discretized with finite differences.

Sparse systems :
- Principle and some strategies for sparse storages,
- Principle of different projection techniques to define iterative methods for solving sparse linear systems,
- Principle of different preconditioning techniques
- Principle of some reordering techniques to solve sparse linear systems with direct methods.

The student will be able to:
Eigenproblems :
Understand the difficulties of a problem, and choose a method.
Paradigms and langages :
At the end of this module, students will be able to develop and to maintain Python / C software codes, to analyze applications performances and to supplement them with MPI/OpenMP directives in order to enable a parallel execution.

Sparse systems :
Chose one or a few methods adapted to a given linear system.

Necessary prerequisites

- Precedent courses on the following subjects : linear algebra, numerical analysis.
- Knowledge of the imperative programmation language main concepts (Python and C).

Practical info

Location(s)

Toulouse

Quality, security, environment

ECTS
2 crédits

Hourly volume
35h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
- Mains concepts and tools for ¿quality¿
- The principles and stakes in the health and in the safety at work.
- The main concepts of the IT security.
- The importance of the environmental strategy in a company.

The student will be able to:
- Integrate the aspects of Quality, Security, Environment into the analysis of problems and the development of solutions.
- Be capable of taking into account the environmental stakes and applying the principles of the sustainable development.

Practical info

Location(s)

Toulouse

Improving one’s autonomy and building one’s own professional project level 2 S7

ECTS
4 crédits

Hourly volume
46h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

Physical and Sports Activities
The student will be able to:
to list the problems to be solved:
¿ Know the Physical and Sports Activity (rules, meaning, roles, etc.),
¿ Design the objective of the project.
to organize:
¿ Know the constraints, the resources, and the means available,
¿ Know how to choose and plan actions over time,
¿ Know how to get involved in the group and the project: know how to adapt, dare to stimulate action, know how to give up, propose, etc.
to regulate:
¿ Know how to observe,
¿ Know how to carry out a balance sheet,
¿ Know how to readjust the choices if necessary.

Individualized Professional Project
The student should be able to:
¿ Develop your professional vision and define a strategy.
¿ Customize, present and compare your project to professionals
¿ Enrich your professional network
¿ Set development axes, objectives and action plans

Necessary prerequisites

Learning outcomes 1st, 2nd, 3rd year.

Practical info

Location(s)

Toulouse

Political sciences semester 1

ECTS
3 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
1 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
2 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
3 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
4 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
5 crédits

Hourly volume

Practical info

Location(s)

Toulouse

Finite Element Methods & Model Reductions

ECTS
4 crédits

Hourly volume

Introducing

Objectives

At the end of this course, the student will have understood and will be able to :

- Write the weak (variational) form of the classical PDE models (with the corresponding energy minimization in symmetric cases).
- Write and code a FE scheme (for linear and non-linear scalar models)

- Develop offline-online strategies to perform reduced basis models in real time (POD and Machine Learning based).

- Employ Finite Element libraries in Python, FEniCS (and FreeFEM++),

Necessary prerequisites

Fundamentals of PDE models and math. analysis, Numerical analysis.

Location(s)

Toulouse

Practical info

Modeling and scientific computing in fluid and structural mechanics

ECTS
4 crédits

Hourly volume
55h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

The fundamentals of Mechanics for fluid and deformable solids, from a physical, mathematical and numerical point of view.

The student will be able to:
- Understand the physical meaning of the various terms used in fluid mechanics and elasticity models.
- Calculate exact solutions of simple problems and interpret them physically
- Evaluate orders of magnitude and know the physical meaning of the main dimensionless numbers
- Formulate and apply a finite volume method for numerically solving simple problems of fluid mechanics
- Formulate and solve the problem of elasticity by means of the finite element method.
- Use an industrial software to model and compute the elasticity problem in static as well as in dynamic.
- Write and implement a mixed formulation to couple different elastic domains and different numerical codes used as black-boxes.

Necessary prerequisites

Fundamentals in:
Continuum mechanics
Numerical analysis
Partial derivative equations

Practical info

Location(s)

Toulouse

Data analysis

ECTS
4 crédits

Hourly volume
58h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
- Data base organisation of R and Python data frames. Syntaxes R and Python languages. R and Python functions design, program and test.
- Statistical analyses of multidimensional data: dimension reduction and clustering with R and Python.
- Statistical interpretation of various graphical displays including the different kinds of factor analyses and clustering.

The student will be able to:
- Manage big data sets with R and Python.
- Lead exploratory data analyses of real big data. It includes univariate, bivariate and multivariate data analyses featuring PCA, MCA, FDA, NMF kmeans, mixture models, DBSCAN¿ depending on data structures and analysis purposes;
- Detect relevant structures within complex data sets and compile insightful interpretations.

Practical info

Location(s)

Toulouse

Stochastic Processes: Time Series and Gaussian Processes

ECTS
4 crédits

Hourly volume
58h

Introducing

Objectives

At the end of this lecture, the student should have acquired the following skills, as well theoretically than practically with the R statistical Software and / or Python.

1) Time series
-Estimate or eliminate the trend and/or the seasonality of a time series
-Study the stationnarity of a time series
-Calculate and estimate the autocorrelogram and the autocorrelograms (total and partial) of a stationary process
-Study and/or adjust an ARMA (or ARIMA) model on a stationary time series
-Carry an optimal linear forecast of an ARMA process

2) Gaussian processes
-Know the fundamental properties of Gaussian processes
-Be able to characterize a Gaussian process through its covariance function
-Be able to use Gaussian Processes for modeling real life situations.

Necessary prerequisites

1) Time series
Probability and Statistics (MIC2) I2MIMT31
Statistics (MIC3) I3MIMT05
Probability and Inferential Statistics (I4MMMT21)

2) Gaussian processes
Advanced probabilities: martingales, stochastic algorithms and Montecarlo methods.
Markov chains.
Integration and probabilities.

Practical info

Location(s)

Toulouse

Signal II and Optimization

ECTS
4 crédits

Hourly volume
50h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

1) Wavelet transform
2) Filter Banks with exact reconstruction
3) Properties of wavelets (localisation in space and frequency) and applications to the approximation of functions.
4) Notion of sub-gradient and proximal operator in convex analysis
5) Basic properties of proximal and Forward-Backward algorithms

The student will be able to:

1) Provide examples of wavelets
2) Carry out numerical approximation of images with wavelets.
3) Identify which convex problems can be solve using the previous algorithms and be able to implement these algorithms on simple cases

Necessary prerequisites

Signal 1
Optimization 1 & 2

Practical info

Location(s)

Toulouse

Project Research – Innovation

ECTS
8 crédits

Hourly volume
55h

Practical info

Location(s)

Toulouse

Machine learning

ECTS
4 crédits

Hourly volume
52h

Introducing

Location(s)

Toulouse

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Properties and limits of the main machine learning algorithms.
- Bias - variance trade-off, model selection.
- Algorithms for risk estimation: bootstrap, cross validation.
- Optimization and algorithmic implementations with R and Python (Scikit-learn) of the studied algorithms.
- Ethical and legal concepts of artificial intelligence.

The student will be able to:
- Analyse big data sets from various domains: insurance, marketing, industry, by using R and Python libraries.
- Execute the main machine learning methods and algorithms (discriminant analysis, k-nn, support vector machines, classification and regression trees, random forests, neural networks..)
- Optimize hyper-parameters values and construct pipelines for automating.
- Optimize the missing values management.
- Detect ethical or legal failures (bias, discrimination, opacity) of machine learning algorithms.

Practical info

Communication in organisations with LV2

ECTS
6 crédits

Hourly volume

Introducing

Objectives

Objectives:
At the end of this module, the student will have understood and be able to explain (main concepts):

-How to answer the demand of the civil society for technical and scientific information
-How to carry out critical analysis in order to give appropriate answers when questioned about such issues
-How to consider the circulation and content of information within the organizations in which they will be hired

The classes given in English will focus on the specific linguistic characteristics of the English used in scientific contexts in order for the students to understand and master them.
The students will also be made aware of the specificities of scientific English as relates to publications in his specific field of research.

Module L 2
The objectives, defined in reference to the CEFRL for the 5 language activities, are specific for the language studied ¿ Chinese, German, Spanish ¿ and the level of the student.
They can be consulted on :
https://moodle.insa-toulouse.fr/course/view.php?id=44

In certain cases, students may be authorised to follow an English module instead of another language

Necessary prerequisites

Necessary knowledge:
For classes in English : understanding of scientific English

Practical info

Location(s)

Toulouse

Political sciences semestre 2

ECTS
3 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
1 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
2 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
3 crédits

Hourly volume

Practical info

Location(s)

Toulouse

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

[FRANCAIS] Challenge – Formation ECIU

ECTS
4 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] Challenge – Formation ECIU

ECTS
5 crédits

Hourly volume

Practical info

Location(s)

Toulouse

Modelling & Scientific Computing

ECTS
4 crédits

Hourly volume
73h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-How to model a problem in physics, biology, economics, etc. using a system of ode or pde
-How to numerically solve such a problem in simple cases

The student should be able to:
-model a problem via ode or pde
-classify problems according to their mathematical structure and choose appropriate numerical methods of solution
-implement (in PYTHON or JULIA) these numerical methods

Necessary prerequisites

Undergraduate courses in analysis and linear algebra.
Basics of Physics
PYTHON language

Location(s)

Toulouse

Practical info

Statistical modelling

ECTS
3 crédits

Hourly volume
76h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-The principle of nonparametric statistical tests for goodness-of-fit, independence, comparison of two populations
-The characteristics of a linear model and a generalized linear model, and their use for statistical modelling

At the end of this module, the student should be able to:

-Choose a test procedure suited to a given problem
-Build nonparametric test procedures to compare two populations
-Build goodness-of-fit tests for a single distribution or a family of distributions
-Choose a linear model or a generalized linear model suited to a given problem
-Estimate the parameters in a linear model and a generalized linear model
-Use statistical tests to validate or invalidate hypotheses on these linear models and generalized linear models.
-Implement a variable selection strategy
-Perform a complete statistical analysis on a real data set using a linear model or a generalized linear model

Necessary prerequisites

Probability: random variables, usual probability laws, expectation, variance, cumulative distribution function, limit theorems, Gaussian vectors, ¿
Inference statistics: moment estimators, maximum likelihood estimators, confidence interval for the mean / the variance for a Gaussian / non-Gaussian sample.
Basics of R software

Practical info

Location(s)

Toulouse

Optimization and Stochastic Optimization

ECTS
4 crédits

Hourly volume
86h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-The theory aiming at caracterise local/global minimum of a real function with or without respect to constraints.

-The main first-order methods in optimisation.

-How to find a subdifferential of a convex function, and a subgradient.

-The worst-case complexity of an algorithm.

At the end of this module, the student should be able to:

-Model and solve an optimisation problem numerically with/without constraint.

Necessary prerequisites

Linear algebra, Calculus, Unconstrained optimisation, Newton and Gauss-Newton algorithms.

Practical info

Location(s)

Toulouse

Data analysis

ECTS
3 crédits

Hourly volume
62h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-The main steps of a data science analysis: preparation, visualization & exploration, prediction, interpretation.
-The main methods in data exploration.
-The main concepts / dangers of statistical learning.
-The main methods of statistical learning on vector data, requiring little expert knowledge / tuning.
-The functioning of R and Python software for data science.

At the end of this module, the student should be able to:

-Solve simple exercises about the underlying mathematical theory.
-Put in action the data science methodology on case studies with R and Python.
-Criticize the assumptions and results, summarize the main conclusions.

Necessary prerequisites

Statistics: descriptive statistics
Probability: random vectors, probability distribution, Bayes law, multivariate normal distribution.
Algebra: vector spaces, Euclidean spaces, matrix calculus, eigenvalue decomposition.
Geometry / mecanics: barycenter, inertia, Huygens formula.

Practical info

Location(s)

Toulouse

Human sciences S7

ECTS
4 crédits

Hourly volume
45h

Introducing

Objectives

ENGLISH
- Develop awareness of scientific publications and presentations
- Prepare students for technical courses given in English on Artificial Intelligence
- Linguaskill preparation for the weakest students

LAW
- Understand the legal structures of companies and how they operate
- Understand the concepts of risk and the resulting responsibilities

Practical info

Location(s)

Toulouse

[FRANCAIS] Formation en entreprise 1

ECTS
12 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] FLE Semestre 7

ECTS

Hourly volume
12h

Practical info

Location(s)

Toulouse

[FRANCAIS] Accompagnement recherche d'entreprise

ECTS

Hourly volume
24h

Practical info

Location(s)

Toulouse

Signal Processing/ Hilbert spaces and Wavelets

ECTS
3 crédits

Hourly volume
69h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-Hilbert Spaces: definition, Hilbertian basis, projection on a convex set, Fourier analysis
-Wavelets: Haar wavelets, connection coefficients/regularity
-Approximation of functions in Hilbert Spaces

At the end of this module, the student should be able to:

-Provide examples of Hilbert spaces
-Give examples of Hilbertian basis
-Fourier analysis of a 1d and 2d signal
-Use and analyze the results of Fast Fourier Transform
-Use and analyse the results of Wavelet transform
-Understand the decomposition of a function in a basis of wavelets.

Necessary prerequisites

Python: numpy, scipy, matplotlib
Fourier Analysis: Fourier Series, Fourier Transform, L^2 space.

Practical info

Location(s)

Toulouse

Infrastructure for cloud and big data

ECTS
3 crédits

Hourly volume
38h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-General concepts of cloud and big data computing infrastructures
-Principles of virtualized infrastructures
-Cloud services
-ools associated with cloud infrastructures
-Principles of big data computing platforms (map-reduce, stream processing)
-Big data treatment environments (Hadoop, Spark, Storm)

At the end of this module, the student should be able to:

-Use virtualization platforms
-Use cloud platforms
-Program big data applications
-Execute big data applications in a computing infrastructure

Necessary prerequisites

Algorithmic, Java programming, Linux environment handling (shell commands)

Practical info

Location(s)

Toulouse

Functional Programming and Graph Theory

ECTS
4 crédits

Hourly volume
81h

Introducing

Objectives

This unit builds on two courses related to the development of complex software:

-Functional programming : Data collecting and network computing applications cannot be programmed efficiently with the common shared memory paradigm (centralized state that can accessed by all components from the application). Functional programming rely on the stateless paradigm derived from the notion of mathematical functions to avoid bottlenecks.

-Graph theory : Graphs are mathematical objects that are used to model many problems relying on complex data. Many dedicated data structures and algorithms have been design to represent and use them efficiently.

Necessary prerequisites

Computer system use
Imperative Programming

Location(s)

Toulouse

Practical info

Machine learning

ECTS
4 crédits

Hourly volume
82h

Introducing

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

-Main concepts and risks of machine learning.
-Advanced methods of machine learning on vector data, requiring tuning effort and/or expert knowledge.
-Ethics of artificial intelligence.

At the end of this module, the student should be able to:

-Solve simple exercises about the underlying mathematical theory.
-Put in action the data science methodology on case studies with R and Python.
-Explain to non-experts the tuning choices in the algorithms.
-Criticize the assumptions and results, summarize the main conclusions.
-Detect legal defects (bias, discrimination) in the algorithms.

Necessary prerequisites

Course « Data science »
Course « Generalized linear model »

Practical info

Location(s)

Toulouse

[FRANCAIS] Développer ses compétences managériales

ECTS
4 crédits

Hourly volume
43h

Practical info

Location(s)

Toulouse

[FRANCAIS] Formation en entreprise 2

ECTS
12 crédits

Hourly volume
12h

Practical info

Location(s)

Toulouse

[FRANCAIS] FLE Semestre 8

ECTS

Hourly volume
12h

Practical info

Location(s)

Toulouse