SCIENCE, TECHNOLOGY, HEALTH

MASTER MATHEMATICAL MODELING & AI

Engineering sciences

Targeted level of education
BAC+5

Duration
année

Component
INSTITUT NATIONAL DES SCIENCES APPLIQUEES TOULOUSE

Introducing

Objectives

Admissions

Access conditions

Target audience

Necessary prerequisites

Recommended prerequisites

Practical info

Location(s)

Toulouse

Program

FOURTH YEAR – MA
4th YEAR MATHEMATICAL MODELING

SEMESTER 7_4th YEAR MA

4th YEAR MA INSA_SEMESTER 7

4th YEAR MA INSA_SEMESTER 7

4th YEAR MA – OPTIONAL COURSES_SEMESTER 7

Liste d'éléments pédagogiques

Partial Derivative Equations & Monte Carlo methods	4 crédits	53h
Advanced probability and Monte Carlo methods	4 crédits	53h

OPTION CSH or IAE

Liste d'éléments pédagogiques

Improve your management abilities	4 crédits	45h
Toulouse School of Management		

Liste d'éléments pédagogiques

Optimisation II	4 crédits	54h
Signal Processing 1	4 crédits	43h
Statistical Modelling	4 crédits	53h
HPC, Matrix Computations and Large Sparse Systems	4 crédits	59h
Quality, security, environment	2 crédits	35h
Improving one's autonomy and building one's own professional project level 2 S7	4 crédits	46h
Political sciences semester 1	3 crédits	

CHALLENGE BASED LEARNING _SEMESTER 1

Liste d'éléments pédagogiques

[FRANCAIS] Challenge – Formation ECIU	1 crédits
[FRANCAIS] Challenge – Formation ECIU	2 crédits
[FRANCAIS] Challenge – Formation ECIU	3 crédits
[FRANCAIS] Challenge – Formation ECIU	4 crédits
[FRANCAIS] Challenge – Formation ECIU	5 crédits

SEMESTER 8_4th YEAR MA

4th YEAR MA INSA_SEMESTER 8

4th YEAR MA INSA_SEMESTER 8

4th YEAR MA OPTIONAL

COURSES_SEMESTER 8

Liste d'éléments pédagogiques

Finite Element Methods & Model Reductions	4 crédits	
Modeling and scientific computing in fluid and structural mechanics	4 crédits	55h
Data analysis	4 crédits	58h
Stochastic Processes: Time Series and Gaussian Processes	4 crédits	58h

Liste d'éléments pédagogiques

Signal II and Optimization	4 crédits	50h
Project Research – Innovation	8 crédits	55h
Machine learning	4 crédits	52h
Communication in organisations with LV2	6 crédits	
Political sciences semestre 2	3 crédits	

CHALLENGE BASED LEARNING _SEMESTER 2

Liste d'éléments pédagogiques

[FRANCAIS] Challenge – Formation ECIU	1 crédits	
[FRANCAIS] Challenge – Formation ECIU	2 crédits	
[FRANCAIS] Challenge – Formation ECIU	3 crédits	
[FRANCAIS] Challenge – Formation ECIU	4 crédits	
[FRANCAIS] Challenge – Formation ECIU	5 crédits	

APPRENTICESHIPS 4th YEAR ModIA

SEMESTER 7_4th YEAR ModIA

Liste d'éléments pédagogiques

Modelling & Scientific Computing	4 crédits	73h
Statistical modelling	3 crédits	76h
Optimization and Stochastic Optimization	4 crédits	86h
Data analysis	3 crédits	62h
Human sciences S7	4 crédits	45h
[FRANCAIS] Formation en entreprise 1	12 crédits	
[FRANCAIS] FLE Semestre 7		12h
[FRANCAIS] Accompagnement recherche d'entreprise		24h

SEMESTER 8_4th YEAR ModIA

Liste d'éléments pédagogiques

Signal Processing/ Hilbert spaces and Wavelets	3 crédits	69h

Infrastructure for cloud and big data	3 crédits	38h
Functional Programming and Graph Theory	4 crédits	81h
Machine learning	4 crédits	82h
[FRANCAIS] Développer ses compétences managériales	4 crédits	43h
[FRANCAIS] Formation en entreprise 2	12 crédits	12h
[FRANCAIS] FLE Semestre 8		12h

FIFTH YEAR – MA
5th YEAR MATHEMATICAL MODELING

SEMESTER 9_5th YEAR MA

5th YEAR MA INSA_SEMESTER 9

5th YEAR MA INSA_SEMESTER 9

OPTIONS COMPULSORY COURSES (1/2)

Liste d'éléments pédagogiques

Computer experiments & Stochastic Calculus with applications to PDE modeling	3 crédits	
Computer Experiments and Experimental Design	3 crédits	

OPTIONAL COURSES (3/7)

Liste d'éléments pédagogiques

Image	3 crédits	36h
Data Assimilation	3 crédits	36h
[FRANCAIS] Volumes finis et Mécanique des fluides avancées	3 crédits	36h
Advanced modeling in computational structural mechanics	3 crédits	35h
Reliability and Lifetime Analysis	3 crédits	36h
IA Frameworks (AIF)	3 crédits	37h
Poisson processes and application to reliability and actuarial sciences	3 crédits	35h

Liste d'éléments pédagogiques

High Dimensional and Deep Learning (HDDL)	3 crédits	40h
Projet 5A + Anglais	9 crédits	42h
Human relations	6 crédits	78h

5th YEAR MA MASTER RESEARCH COMPUTING AND TELECOMMUNICATION

Liste d'éléments pédagogiques

Image	3 crédits	40h
Research project, innovation, Engineering English	9 crédits	12h

[FRANCAIS] MASTER RECHERCHE INFORMATIQUE & TELECOM	9 crédits	

5th YEAR THEME RISK ENGINEERING

Liste d’éléments pédagogiques

Qualitative Approach	4 crédits	45h
Quantitative Approach	5 crédits	45h
Designing for safety	5 crédits	42h
Process Safety	5 crédits	45h
Functional Safety		
[FRANCAIS] Structural Safety		
Human relations	6 crédits	78h
Toxic risks	5 crédits	42h

CHALLENGE BASED LEARNING _SEMESTER 1

Liste d’éléments pédagogiques

[FRANCAIS] Challenge – Formation ECIU	1 crédits	
[FRANCAIS] Challenge – Formation ECIU	2 crédits	
[FRANCAIS] Challenge – Formation ECIU	3 crédits	
[FRANCAIS] Challenge – Formation ECIU	4 crédits	
[FRANCAIS] Challenge – Formation ECIU	5 crédits	

SEMESTER 10 5th YEAR MA

Liste d’éléments pédagogiques

Training period 5th year	21 crédits	
Training period 4th year	9 crédits	

APPRENTICESHIPS 5th YEAR ModIA

SEMESTER 9_5th YEAR ModIA

Liste d’éléments pédagogiques

Data Assimilation	3 crédits	69h
Modeling & Finite Elements	3 crédits	68h
Design of experiments and metamodels	3 crédits	64h
[FRANCAIS] Processus de Poisson et applications	4 crédits	59h
Human sciences	3 crédits	41h
[FRANCAIS] Formation en entreprise 3	14 crédits	

SEMESTER 10_5th YEAR ModIA

Liste d’éléments pédagogiques

High Dimensional Statistics and Deep Learning	3 crédits	60h
High Performance Scientific Computing	3 crédits	59h
Physics contrained machine learning	3 crédits	59h
Trusted Systems	3 crédits	60h
IA Frameworks	3 crédits	24h
[FRANCAIS] Formation en entreprise 4	15 crédits	

APPRENTICESHIPS 6th YEAR ModIA

SEMESTER 11_6th YEAR ModIA

Liste d’éléments pédagogiques

[FRANCAIS] PFE en Entreprise	30 crédits	96h

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

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

Management I3CCGE51

Practical info

Location(s)

Toulouse

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Project Research – Innovation

ECTS
8 crédits

Hourly volume
55h

Practical info

Location(s)

Toulouse

Machine learning

ECTS
4 crédits

Hourly volume
52h

Introducing

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.

Location(s)

Toulouse

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

[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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 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

Computer experiments & Stochastic Calculus with applications to PDE modeling

ECTS
3 crédits

Hourly volume

Introducing

Objectives

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

Computer Experiment
· Metamodelling for optimization / uncertainty quantification of a computer code
· At least the two main families of metamodels : chaos polynomials and Gaussian processes
· Kernel customization to account for external knowledge
· Design of computer experiments
· Global sensivity analysis
Stochastic calculus
· The brownian motion as well as the Wiener integral and Itô¿s formula
· The relationship between a stochastic differential equation and its Fokker-Planck equation.
· The rewriting of a parabolic or elliptical problem using a well-chosen stochastic process.

The student should be able:
Computer Experiments
· At a theoretical level, to do computations for:
· covariance kernels and Gaussian process
· ANOVA decomposition, Sobol indices
· At a practical level, to perform the complete methodology for analyzing a computer code
· design of experiments
· metamodel construction / evaluation
· application to optimization / uncertainty quantification of a computer code
Stochastic calculus
· Derive simple models on noise filtration and stochastic control.
· Numerically implement the resolution of a parabolic or elliptic equation using a particle-based probabilistic method.

Necessary prerequisites

Gaussian vectors. Probability. ODE. Basics of PDE.

Practical info

Location(s)

Toulouse

Computer Experiments and Experimental Design

ECTS
3 crédits

Hourly volume

Introducing

Objectives

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

-The main methods of experimental design
-Metamodelling for optimization / uncertainty quantification of a computer code
-At least the two main families of metamodels : chaos polynomials and Gaussian processes
-Kernel customization to account for external knowledge
-Design of computer experiments
-Global sensivity analysis

The student should be able:
Experimental Design part.
-Plan an experiment in the framework of a linear model
Computer Experiment part.
-At a theoretical level, to do computations for:
-covariance kernels and Gaussian process
-ANOVA decomposition, Sobol indices
-At a practical level, to perform the complete methodology for analyzing a computer code
-design of experiments
-metamodel construction / evaluation
-application to optimization / uncertainty quantification of a computer code

Necessary prerequisites

Statistical modelling

Softwares and Methods of Statistical Exploratory Data Analysis

Gaussian vectors.

Practical info

Location(s)

Toulouse

Image

ECTS
3 crédits

Hourly volume
36h

Introducing

Objectives

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

The image acquisition process, the basics and the use of optimization methods for solving inverses problems meet in image processing. The main applications are image restoration, segmentation and registration.

The student will be able to:
manipulate, implement and perform tests on novel image processing methods. In order to do so, the student will need to calculate the gradients, projections and proximal operators he needs to implement an algorithm adapted to structure of his problem.

Necessary prerequisites

-Basics in linear algebra
-Basics in non-linear optimization
-Basics in statistics and probability
-Basics in programming

Practical info

Location(s)

Toulouse

Data Assimilation

ECTS
3 crédits

Hourly volume
36h

Introducing

Objectives

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

(Data Assimilation part)
- write an optimal control problem formulation, both for ODE models and PDE models

- combine at best a PDE model with datasets.

- compute a gradient using the adjoint method.

- set up algorithms of parameters identification, model calibration (3D-Var, 4D-Var etc)

- explain the equivalencies between VDA, BLUE, Kalman filtering and Bayesian approach in the Linear-Quadratic-Gaussian case

- introduce prior probabilistic information via covariances matrix

(Model learning part)

- set up a model learning method from datasets and an a-priori given dictionary.
Both for ODE or (scalar) PDE models.

The student will be able to:

Set up the equations and the complete modeling chain to perform parameters identification / model calibration / Variational Data Assimilation for PDE models.

Identify the dominant model terms from measurements .

Necessary prerequisites

Basics of: PDE models, differential calculus, optimisation, functional analysis, numerical schemes, Python programming.

Practical info

Location(s)

Toulouse

[FRANCAIS] Volumes finis et Mécanique des fluides avancées

ECTS
3 crédits

Hourly volume
36h

Introducing

Objectives

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

-the different models used to describe the dynamics of turbulent flows
-the principles and the theoretical background of the finite volume methods used in computational fluid dynamics.

This course completes and deepens the basic notions of the S8 course entitled: "Numerical models and methods for fluid and structural mechanics".

The student will be able to:
-Understand the models used to describe the dynamics of turbulent flows,
-Know the underlying assumptions and the limits of validity of these models,
-Know/understand the main numerical methods used in CFD and apply them,
-Use a model and a numerical method adapted to the fluid mechanics problem to be solved and the desired accuracy.

Necessary prerequisites

Basic skills in computational fluid mechanics (dynamics of incompressible flows, general principles of the finite volume method)

Practical info

Location(s)

Toulouse

Advanced modeling in computational structural mechanics

ECTS
3 crédits

Hourly volume
35h

Introducing

Objectives

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

A few advanced modelling methods in structural mechanics to tackle current real applications such as:
- computation of shell-type structures;
- use of CAD data for the computation;
- model and computation of contact problems between elastic bodies;
- image registration in view of performing data ¿ model comparison in experimental mechanics.

The student will be able to:

On simple cases:

- Formulate and solve by the FEM beam models.
- Apprehend a computational technique based on the exact geometric representation in CAD (NURBS-based isogeometric analysis).
- Formulate and solve using various finite elements algorithms a frictionless contact problem
- Apprehend the data-driven (model-free) paradigm in computational mechanics.
- Identify material properties by image data - model comparison.

Necessary prerequisites

- Continuum mechanics.
- Elasticity modelling.
- Finite element method.

Practical info

Location(s)

Toulouse

Reliability and Lifetime Analysis

ECTS
3 crédits

Hourly volume
36h

Introducing

Objectives

At the end of this module, the student will be able to drive the following process and to explain the obtained conclusions

-Using the Reliability database in order to estimate the functions of interest
-Analyzing and exploiting the structure of a system to derive its reliability from the characteristics of its components
-Modeling the recursive occurrences of the failures on a system. Modeling the évolution of the system-state with time.
-Modeling the effect of maintenance and its planning according to the observations made on the system (dégradation process in particular)

Necessary prerequisites

-Markov chains and applications (MIC3)
-Inferential Statistics (MIC3)
-Statistical Modelling (GMM4)

Practical info

Location(s)

Toulouse

IA Frameworks (AIF)

ECTS
3 crédits

Hourly volume
37h

Introducing

Objectives

This course follows the Machine Learning and the High Dimensional & Deep Learning. At the end of this module, the student will be able to run efficiently these algorithms on various technology. It will also learn different algorithms on real dataset.

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

- Properties of container images.
- Properties of cloud computing.
- Main algorithms of Natural language processing. ((Cleaning, Vectorization, Word embedding)
- Reinforcement learning.
- Main recommendation system algorithm.

The student will be able to:
- Clean, prepare, transform (munging) big data within Python or Spark frameworks.
- Identify the right tool to analyse these big data (virtual machine ,container, gpus, etc..) on different use case.
- Identify the right algorithm according to the data (recommendation system, NLP, rreinforcement learning, cnn
- Execute, optimize, these methods and algorithms in the best adapted framework and validate their performances.
- Learn by himself and develop a use case for a recent technology of his choice.

Necessary prerequisites

Exploratory Data Analysis
Machine Learning / Deep Learning
R and Python languages

Practical info

Location(s)

Toulouse

Poisson processes and application to reliability and actuarial sciences

ECTS
3 crédits

Hourly volume
35h

Introducing

Objectives

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

-Know and understand the Poisson process theory fundamentals.
-Estimate the rate of a homogeneous Poisson process and construct confidence intervals and statistical tests for such rate (theoretically and in practice with the R Statistical Software).
-Model the recursive occurrences of the failures on a system, or the claim times in Insurance by Poisson processes.

Necessary prerequisites

-Probability and Statistics (I2MIMT31)
-Statistics (I3MIMT41)
-Elements of Statistical Modeling (I4MATCEMS11)

Practical info

Location(s)

Toulouse

High Dimensional and Deep Learning (HDDL)

ECTS
3 crédits

Hourly volume
40h

Introducing

Objectives

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

-The aggregation of learning methods via boosting algorithms
-Using deep learning methods for classification in high dimension
-Classification of signals or images
-Estimation of the prediction error
-Dimension reduction by projection onto orthonormal bases
-Anomaly detection algorithms
-Recurent neural networks for time series forcasting

The student will be able to:

-Implement and optimize boosting algorithms on datasets
-Fit a deep neural network for signal or image classification
-Apply anomaly detection algorithms
-Use recurent neural networks for time series forcasting
-Implement deep learning methods in high dimension on real data sets with the software R or Python's libraries.

Necessary prerequisites

Statistical modelling
Machine Learning
Software for statistics (R,Python)

Practical info

Location(s)

Toulouse

Projet 5A + Anglais

ECTS
9 crédits

Hourly volume
42h

Practical info

Location(s)

Toulouse

Human relations

ECTS
6 crédits

Hourly volume
78h

Introducing

Objectives

L'étudiant devra être capable de :
-Analyser des situations de groupe avec des concepts issus de la psychologie sociale
-Identifier les dimensions éthiques de ces situations et prendre position
-Repérer et comprendre des informations liées aux RH
-Analyser une situation de management d¿équipe en référence à un cadre théorique
-Formuler et argumenter des solutions managériales
-Agir dans un milieu naturel : analyser, décider, agir ; mettre en œuvre la sécurité, utiliser du matériel spécifique. découvrir un site.
-Respecter et s'intégrer dans un environnement différent de ses habitudes
-S'engager avec cohérence dans le projet d'activités
-Prendre part activement au collectif
-Valider son projet professionnel et construire une stratégie pour trouver un emploi

Necessary prerequisites

None

Location(s)

Toulouse

Practical info

Image

ECTS
3 crédits

Hourly volume
40h

Practical info

Location(s)

Toulouse

Research project, innovation, Engineering English

ECTS
9 crédits

Hourly volume
12h

Practical info

Location(s)

Toulouse

[FRANCAIS] MASTER RECHERCHE INFORMATIQUE & TELECOM

ECTS
9 crédits

Hourly volume

Practical info

Location(s)

Toulouse

Qualitative Approach

ECTS
4 crédits

Hourly volume
45h

Practical info

Location(s)

Toulouse

Quantitative Approach

ECTS
5 crédits

Hourly volume
45h

Practical info

Location(s)

Toulouse

Designing for safety

ECTS
5 crédits

Hourly volume
42h

Practical info

Location(s)

Toulouse

Process Safety

ECTS
5 crédits

Hourly volume
45h

Practical info

Location(s)

Toulouse

Functional Safety

Practical info

Location(s)

Toulouse

[FRANCAIS] Structural Safety

Practical info

Location(s)

Toulouse

Human relations

ECTS
6 crédits

Hourly volume
78h

Introducing

Objectives

L'étudiant devra être capable de :
-Analyser des situations de groupe avec des concepts issus de la psychologie sociale
-Identifier les dimensions éthiques de ces situations et prendre position
-Repérer et comprendre des informations liées aux RH
-Analyser une situation de management d¿équipe en référence à un cadre théorique
-Formuler et argumenter des solutions managériales
-Agir dans un milieu naturel : analyser, décider, agir ; mettre en œuvre la sécurité, utiliser du matériel spécifique. découvrir un site.
-Respecter et s'intégrer dans un environnement différent de ses habitudes
-S'engager avec cohérence dans le projet d'activités
-Prendre part activement au collectif
-Valider son projet professionnel et construire une stratégie pour trouver un emploi

Necessary prerequisites

None

Practical info

Location(s)

Toulouse

Toxic risks

ECTS
5 crédits

Hourly volume
42h

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

Training period 5th year

ECTS
21 crédits

Hourly volume

Practical info

Location(s)

Toulouse

Training period 4th year

ECTS
9 crédits

Hourly volume

Practical info

Location(s)

Toulouse

Data Assimilation

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):

-The general concepts behind Data Assimilation
-The key step to predict the state of a system by combining models and observations: formal definition of a dynamical system, error specification, interpretation of results
-Methods fro handling nonlinearity and large scale
-Variationnal methods for Data Assimilation
-Ensemble methods for Data Assimilation

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

-Analytically solve a vairaitonnal Data Assimilation problem
-Design a data assimilation system using a description of a system using partial differential equation
-Assess the performance of a system, question the relevance of the mathematical assumptions

Necessary prerequisites

Numerical algebra for large scale, statistical estimation, non-convex smooth optimization, numerical solution of PDEs

Practical info

Location(s)

Toulouse

Modeling & Finite Elements

ECTS
3 crédits

Hourly volume
68h

Introducing

Objectives

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

-How to model and to compute with the Finite Element Method (FEM) classical systems of PDEs.

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

¿ write the weak (variational) form of the classical PDE models (with the corresponding energy minimization, symmetric case).
¿ Understand the mathematical analysis of classical PDE models.
¿ Model and compute with the FEM various classical phenomena (diffusive, convective, elasticity, etc.) which are ubiquitous in physics, process.
¿ Employ Finite Element libraries, e.g. Fenics (in Python)
¿ Implement advanced computational techniques in case of large-scale modeling (model reduction, coupling of numerical models and codes).

Necessary prerequisites

Fundamentals of PDE models, math. analysis,

Basic numerical methods-analysis.

Practical info

Location(s)

Toulouse

Design of experiments and metamodels

ECTS
3 crédits

Hourly volume
64h

Introducing

Objectives

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

-The main methods of experimental design
-Metamodelling for optimization / uncertainty quantification of a black-box function
-At least the two main families of metamodels : chaos polynomials and Gaussian processes
-Kernel customization to account for external knowledge
-Design of computer experiments
-Global sensitivity analysis

The student should be able:

Experimental Design part.
-Plan an experiment in the framework of a linear model

Metamodels part.
-At a theoretical level, to do computations for:
-covariance kernels and Gaussian process
-ANOVA decomposition, Sobol indices
-At a practical level, to perform the complete methodology for analyzing a black-box function :
-design of experiments
-metamodel construction / evaluation
-application to optimization / uncertainty quantification

Necessary prerequisites

Linear model, Gaussian vectors.

Practical info

Location(s)

Toulouse

[FRANCAIS] Processus de Poisson et applications

ECTS
4 crédits

Hourly volume
59h

Introducing

Objectives

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

· Analyze and exploit the structure of a system to derive its reliability from the characteristics of its components.
· Model the recursive occurrences of the failures on a system or the claim times in insurance by Poisson processes.
· Compute or approximate the ruin probability of insurance derivatives. Use machine learning techniques in actuarial sciences.
· Know the theoretical foundations of the Monte-Carlo method and be able to make use of it within the scope of its applicability and limitations.

· Identify the specific linguistic characteristics of the English used in scientific contexts, and to present their work orally and in written form following this scientific style.
· Write a scientific report in English on their project, respecting the conventions of their field.
· Present project work orally in English and dialogue on key elements of their project in a structured manner.
· Select relevant information for specific audiences.
· Explain complex scientific and technical concepts to non-specialists.
· Adapt their expression for formal and informal presentations.

Necessary prerequisites

-Markov chains and applications (MIC3)
-Inferential Statistics (MIC3)
-Statistical Modelling (ModIA S7)

Practical info

Location(s)

Toulouse

Human sciences

ECTS
3 crédits

Hourly volume
41h

Introducing

Objectives

Aims
The student will learn how to:
¿ Analyze group situations using social psychology concepts
¿ Identify the ethical dimensions of these situations and take a stance
¿ Identify and understand HR-related information
¿ Analyze a team management situation in a theoretical context
¿ Formulate and justify managerial decisions
¿ Take an active role within the group
¿ Fulfill their career objectives, build a strategic plan and acquire job searching skills

Necessary prerequisites

None

Practical info

Location(s)

Toulouse

[FRANCAIS] Formation en entreprise 3

ECTS
14 crédits

Hourly volume

Practical info

Location(s)

Toulouse

High Dimensional Statistics and Deep Learning

ECTS
3 crédits

Hourly volume
60h

Introducing

Objectives

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

-How to use deep learning methods for classification in high dimension
-Classification of media or images
-Estimation of the prediction error
-Dimension reduction by projection onto orthonormal bases
-Anomaly detection
-Application of deep learning methods on real data set

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

-Fit a deep neural network for media or image classification and regression
-Apply anomaly detection algorithms
-Implement deep learning methods in high dimension on real data sets with Python libraries.

Necessary prerequisites

Statistical modelling
Software for statistics

Practical info

Location(s)

Toulouse

High Performance Scientific Computing

ECTS
3 crédits

Hourly volume
59h

Introducing

Objectives

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

· the principle of Krylov's methods to solve linear systems or compute eigenvalues and eigenvectors,
· the concept of preconditioning, the construction and use of preconditioners,
· theory and basic concepts of direct methods for sparse linear systems. Operating complexity and parallelism of direct methods,
· basic notions of parallel computer architecture, programming models for shared memory (OpenMP) and distributed memory (MPI) systems,
· basic concepts and methods for analyzing the performance of a parallel algorithm or code (Amdahl's law, cache hierarchy, principles of spatial and temporal locality, roofline model, critical path computation and high and low scalability).

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

· evaluate the costs (flops/memory) of the different methods,
· analyze the influence of preconditioners,
· use high-level languages for the discretization of partial differential equations,
· program solvers, to parallelise simple codes according to the most adequate standard and to execute them on the appropriate resources,
· to analyse the efficiency of a method with regard to the operational complexity, the computing time and the memory footprint used in a high-performance computing perspective.

Necessary prerequisites

· Courses in Linear Algebra or Scientific Calculus, in particular the factorization methods LU or Cholesky
· Basics of computer architecture and imperative programming languages

Practical info

Location(s)

Toulouse

Physics contrained machine learning

ECTS
3 crédits

Hourly volume
59h

Introducing

Objectives

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

-Main approaches for solving time dependent problem (EDP and Data assimilation) using ML
-Relevance of using physical constraints for solving problems with underling physics (feature engineering), design of Neural networks
-Methods for handling nonlinearity and large scale (use of latent space, high performance computing)
-Performance of ML for solving problems with physical constraints.

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

-Use ML for solving time dependent PDE and analysis the accuracy
-Analysis the HP performance of the solvers, and propose algorithmic enhancements
-Design a full data assimilation system based on ML, starting from a description of a system using partial differential equation and and observational system
-Assess the performance of a system, question the relevance of the mathematical assumptions

Necessary prerequisites

Numerical algebra for large scale, statistical estimation, non-convex smooth optimization, numerical solution of PDEs, data assimilation, machine learning

Practical info

Location(s)

Toulouse

Trusted Systems

ECTS
3 crédits

Hourly volume
60h

Introducing

Objectives

Software play a key role in many industrial domains, including safety critical ones (transportation, health, business, ¿) where defects can have a strong direct, or indirect, impact on human life.

This UE provides 2 courses that contribute to improving the quality of software and the trust we can have in it.

-Software and System Engineering provides the core concepts needed to build trusted software intensive systems. Model Driven Engineering will be a core element as it allows to model application domain specific elements and to ease the building of domain specific tools.

-Modeling, Resolution and Proof provides the elements from discrete mathematics that allowing modeling formally the requirements for software systems and to carry formal proof of correctness about their behavior. These elements are also at the root of symbolic artificial intelligence in order to model knowledge, structured data and to explain the decision taking by systems. We will also illustrate how these tools can be used for discrete optimization.

This UE tackles both the theoretical knowledge and methods, and their use in representative tools.

Necessary prerequisites

Computer use
Programming
Basic general algebra

Practical info

Location(s)

Toulouse

IA Frameworks

ECTS
3 crédits

Hourly volume
24h

Introducing

Objectives

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

- Main concept of data labelisation and related tools.
- Main algorithms of natural language processing
- Main concepts of reinforcement learning.
- Main concepts of recommendation system.
- How to access tools to perform efficiently and with enough computation power those algorithms

The student will be able to:

- Organize en data labelisation strategy.
- Handle various types of complex datasets (Image, text, video, notations,...)
- Identify the correct algorithm to solve various problem on these data.
- run these algorithms on the appropriate ressource (cloud machine, container? GPU?)
- Share efficiently the results obtain

Necessary prerequisites

Exploratory Data Analysis
Machine Learning / Deep Learning (MLP, RNN, CNN)
R and Python languages

Practical info

Location(s)

Toulouse

[FRANCAIS] Formation en entreprise 4

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