FIFTH YEAR – MA

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

Location(s)

Toulouse

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

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

Practical info

Location(s)

Toulouse

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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 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

Location(s)

Toulouse

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

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

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

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

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES 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

ECTS
15 crédits

Hourly volume

Practical info

Location(s)

Toulouse

[FRANCAIS] PFE en Entreprise

ECTS
30 crédits

Hourly volume
96h

Practical info

Location(s)

Toulouse