APPRENTICESHIPS 5th YEAR ModIA

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

ECTS
15 crédits

Hourly volume

Practical info

Location(s)

Toulouse