ENSIIE

COURSES CATALOGUE

2021–2022

CONTENTS

SEMESTERS 1 AND 2

The first two semesters are fully composed of compulsory teaching units. Theses semesters give scientific and theoretical basis needed for the other semesters. The students follow 6 technical teaching units (42 hours, 4 ECTS) and 2 non technical teaching units - foreign languages, business organisations - (45 hours, 3 ECTS).

SEMESTER 1

Contents

[ANNU11] MÉTHODES D'ANALYSE NUMÉRIQUE (4 ECTS)

UE resp : TORRI Vincent

Prerequisite (in french) : None

[CBDR11] CONCEPTION DE BASES DE DONNÉES RELATIONNELLES

(4 ECTS)

UE resp : SZAFRANSKI Marie

Prerequisite (in french) : None

Aims :

This course aims to provide methodological and technical concepts on relational databases. At the end of this course, the students will be able to design a normalized relational database, to create a database ensuring the consistency and the integrity of the data and to efficiently manipulate its information.

Content :

- General concepts
- Conceptual and relational modeling
- Database normalization
- SQL : basics and advanced
- Transactions

[GROP11] GRAPHES ET OPTIMISATION (4 ECTS)

UE resp : MERABET Massinissa

Prerequisite (in french) : None

Aims :

The objective of the graphs and optimization UE is to allow students to discover graph theory and to master its fundamentals. This opens up a large field of modeling leading to effective solutions for many problems in various fields: planning, logistics, transport, etc. The notion of discrete optimization (operational research) and graph algorithms is also addressed through the presentation of several algorithms solving problems in graphs.

[OUMA11] OUTILS MATHÉMATIQUES (4 ECTS)

UE resp : MOUILLERON Christophe

Prerequisite (in french) : None

Aims :

The goal of this course is to give a solid knowledge in mathematics to the students, so that they can comfortably take the other mathematics courses of the formation. Several concepts useful to any future engineer are introduced during this course, and then put into practice through many exercises.

Content :

- Real functions
- Taylor polynomials, asymptotic analysis
- Integrability, methods for computing a definite integral
- Complex numbers
- Matrices (determinant, inverse), matrix diagonalization
- Numerical sequences and series, power series
- Multivariate functions

[PRIM11] PROGRAMMATION IMPÉRATIVE (4 ECTS)

UE resp : BUREL Guillaume

Prerequisite (in french) : None

Aims :

This course aims at giving students the opportunity to choose or design the data structure which is the most adapted to the resolution of their problem and then to choose the language and the most comfortable programming style to use it, following an engineer's approach. The Imperative Programming course introduces the structures of mutable data and side effects. It precedes the functional programming course organized around the notion of persistent data structures.

Content :

- Memory model;
- syntax basis;
- call by value/reference;
- static data structures : arrays, algorithms on arrays;
- dynamic structures (allocation/free) : linked lists;
- modularity and separate compilation.

[PROB11] PROBABILITÉS (4 ECTS)

UE resp : LY VATH Vathana

Prerequisite (in french) : None

Aims :

The aim of this course is to familiarize students with the basics of probability theory which will subsequently be useful for tackling more elaborate courses, particularly in statistical modeling, stochastic processes and mathematical finance.

Content :

- Probability spaces,
- Discrete random variables (real or vector), Continuous random variables (real or vector), usual laws,
- Expectations, conditional laws and expectations, characteristic functions,
- Convergences and limit theorems,
- Gaussian Vectors

[OSSE11] INTRODUCTION AU SYSTÈME D'EXPLOITATION (4 ECTS)

UE resp : RIOBOO Renaud

Prerequisite (in french) : None

[ECGE11] ECONOMIE-GESTION 1 (3 ECTS)

UE resp : ABDELLAOUI Mohamed

Prerequisite (in french) : None

Aims :

The goal of this UE is to introduce the basic notions about macro-economy, account management and sustainable development.

Module 1 Macro-économie

Module 2 Gestion comptable et financière

Module 3 Enjeux environnementaux et développement durable

MACRO-ÉCONOMIE

GESTION COMPTABLE ET FINANCIÈRE

ENJEUX ENVIRONNEMENTAUX ET DÉVELOPPEMENT DURABLE

[LVFH11] FORMATION HUMAINE (3 ECTS)

UE resp : BOURARD Laurence

Prerequisite (in french) : None

Aims :

Improving and practicing one's skills in English and one other foreign language.

Understanding the communication process to better one's skills and become an effective speaker/writer/facilitator.

Module 1 LV1

Module 2 LV2

Module 3 La communication au service de l'étudiant

LV1

Aims : English skills for the global engineer/successful business interactions.

Improving language proficiency and reaching the B2 level of the CEFR or higher (Common European Framework of Reference for Languages)

Content :

Class discussions and tasks based on authentic audio and video recordings, current events and real-life contexts.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing.

Preparing for different certifying test formats - online and offline practice.

LV2

Aims : Being able to (better) communicate in one of the following foreign languages:

German, Chinese, Spanish, French, Italian, Japanese, Russian.

Content :

Class discussions and tasks are based on authentic and semi-authentic materials (audio/video recordings, news articles, textbooks). Topics and level of difficulty will vary according to students' language proficiency.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing, Learning about a foreign culture.

LA COMMUNICATION AU SERVICE DE L'ÉTUDIANT

Aims : Communication strategies in the workplace

Understanding and honing interpersonal skills

Content :

Mastering the basics of oral communication

Nervousness, body language

Becoming an effective speaker, making a convincing argument

SEMESTER 2

Contents

[IPFL12] INTRODUCTION À LA PROGRAMMATION FONCTIONNELLE ET LOGIQUE

(4 ECTS)

UE resp : FOREST Julien

Prerequisite (in french) : None

Aims :

Two main goals are addressed. The first one is to introduce the functional programming paradigm, the second one is two give some basic notions in formal logic.

Module 1 Introduction à la programmation fonctionnelle

Module 2 Logique

INTRODUCTION À LA PROGRAMMATION FONCTIONNELLE

Aims : In this course, we introduce the notion of **functionnal programming**. The course is mainly focalised on the notion of **persistent data structures** and their iterators. In particular, the courses presents some common basic datastructure and the notion of polymorphism.

Content :

This course is illustrated using the Ocaml language.

The main introduced notions are:

- Functional kernel and exceptions,
- Inductive types,
- Polymorphic types,
- List, tree and their iterator.

LOGIQUE

Aims : Introduction to formal logic and to formal proofs.

Content :

Two main goals are addressed. The first one is to introduce the functional programming paradigm, the second one is two give some basic notions in formal logic.

The course first introduces the inductive objects (set, functions and proof) and of well-founded induction.

The second part presents the propositional logic: syntax, semantic and both natural deduction and resolution formal systems

The third part extents the second one to the first order logic.

Finally, the link with functional programming is mentioned via an informal presentation of the Curry-Howard isomorphism.

[LAOB12] LANGAGES OBJET (4 ECTS)

UE resp : ROUSSEL David

Prerequisite (in french) : None

Aims :

The main goal of this teaching unit is to master object concepts used in Object Oriented languages and the basics of object modeling through Java and C ++ languages using UML notation.

Content :

The main goal of this teaching unit is to master object concepts used in Object Oriented languages and the basics of object modeling through Java and C ++ languages using UML notation.

[OPMA12] OPTIMISATION (4 ECTS)

UE resp : FAYE Alain

Prerequisite (in french) : None

[PRIM12] PROJETS INFORMATIQUE ET MATHÉMATIQUE (4 ECTS)

UE resp : WATEL Dimitri

Prerequisite (in french) : None

Aims :

The goal of this course is to make students work together on a subject using the knowledge acquired during the courses of the first year. It is split into three parts, a **computer science project** in which the students develop a software, a **web project** in which the students develop a website and a **mathematical project** in which the students model a problem using mathematical tools.

Module 1 Projet informatique

Module 2 Projet mathématique

Module 3 Projet web

PROJET INFORMATIQUE

Aims : In this project, the students works in a team on the development of a software in C. The teamwork is essential and is done by using tools like Git or GanttProject. The monitoring of the project is done during the sessions of the course, in which the teams are guided and helped and in which the work of each member of the group is checked.

Content :

A course describing the tools that are used during the project (Makefile, Git, Ganttproject) and the subject. Then multiple sessions to do the project with a group of 4 students.

PROJET MATHÉMATIQUE

PROJET WEB

[PWRD12] PROGRAMMATION WEB ET RÉSEAUX DE DONNÉES (4 ECTS)

UE resp : RIOBOO Renaud

Prerequisite (in french) : None

Module 1 Programmation web

Module 2 Réseaux de données

PROGRAMMATION WEB

RÉSEAUX DE DONNÉES

[STAT12] STATISTIQUES (4 ECTS)

UE resp : BRUNEL Nicolas

Prerequisite (in french) : None

Aims :

This course is an introduction to statistical thinking and to the key concepts of statistical inference. We discuss the notion of statistical model, likelihood, statistical inference. We present the properties of classical estimators (risk consistency, efficiency and Fisher information...) for point estimation and confidence intervals (exact and asymptotic). Tests theory (Neyman-Pearson approach) is introduced in classical cases, as well as of goodness-of-fit tests. These different concepts are implemented with the R language both on simulated data and on real data.

[ECGE12] ECONOMIE-GESTION 2 (3 ECTS)

UE resp : CASTELNAU Philippe

Prerequisite (in french) : None

Aims :
Introduction to micro-economy and finance

Module 1 Micro-économie

Module 2 Introduction à la Finance : banque et entreprise

MICRO-ÉCONOMIE

INTRODUCTION À LA FINANCE : BANQUE ET ENTREPRISE

Aims : This course aims at providing students engineers with an introduction to banks, their business models and their related professions, to deep dive into specific topics where engineers can play an important role, such as risk management, front-office and information systems. The course also aims at introducing financial authorities and significant organisations such as central banks and rating agencies. Finally, it is also the opportunity to tackle notions related to corporate finance.

Content :
Banks' business models : retail, investment, project finance, etc.

Risk management: credit, market, operational, liquidity, climate change

Financial authorities, rating agencies

Banks' governance, organisation, crisis prevention and management

Digitalisation and cyber security in a bank

Accounting and financial items: banks and corporates

Investment analysis tools and business valuation

[LVFH12] LANGUES VIVANTES ET FORMATION HUMAINE (3 ECTS)

UE resp : BOURARD Laurence

Prerequisite (in french) : None

Aims :

Improving and practicing one's skills in English and one other foreign language.

Understanding the communication process to better one's skills and become an effective speaker/writer/facilitator.

Module 1 LV1

Module 2 LV2

Module 3 La communication au service de l'étudiant

LV1

Aims : English skills for the global engineer/successful business interactions.

Improving language proficiency and reaching the B2 level of the CEFR or higher (Common European Framework of Reference for Languages)

Content :

Class discussions and tasks based on authentic audio and video recordings, current events and real-life contexts.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing.

Preparing for different certifying test formats - online and offline practice.

LV2

Aims : Being able to (better) communicate in one of the following foreign languages:

German, Chinese, Spanish, French, Italian, Japanese, Russian.

Content :

Class discussions and tasks are based on authentic and semi-authentic materials (audio/video recordings, news articles, textbooks). Topics and level of difficulty will vary according to students' language proficiency.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing, Learning about a foreign culture.

LA COMMUNICATION AU SERVICE DE L'ÉTUDIANT

Aims : Communication strategies in the workplace

Understanding and honing interpersonal skills

Content :

Mastering the basics of oral communication

Nervousness, body language

Becoming an effective speaker, making a convincing argument

SEMESTERS 3 AND 4

During semesters 3 and 4 , the students select 6 technical teaching units among the possible options (42 hours, 4ECTS). They also follow 2 compulsory non technical teaching units (42 hours, 3 ECTS)

SEMESTER 3

Organisation.
Student have to choose 6 technical teaching units (cf Figure 1): 1 teaching unit must be choosen in each column.

Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	Gr. 6	TC	TC
MERR23	PRST23	ANAF23	PRAP23	ANDO23	REOP23	ECGE23	LVFH23
LFVL23	PRFO23	PIMA23	ASCO23	GELO23	SERM23		
ARMA23			PRPA23	ARSE23	INPS23		
DJVU23				LODM23			

Figure 1: Teaching units of S3

Options (teaching units of each option)

- *Calcul Intensif et Données Massives* (CIDM) Resp. Pierre Dossantos-Uzarralde : PIMA23,PRPA23,ARSE23,MERR23/ARMA23,INPS23
- *Génie logiciel* (GL) Resp Guillaume Burel : PIMA23, PRFO23, LFVL23/ARMA23, GELO23, SERM23/REOP23, ASCO23
- *Interactions Numériques* (IN) Resp. Guillaume Bouyer : PIMA23, LFVL23, DJVU23, GELO23/ANDO23, SERM23
- *Mathématiques appliquées* (MA) Resp. Sergio Pulido Nino: PIMA23/ANAF23, PRST23, MERR23, PRAP23, ANDO23, REOP23

Contents

[ANAF23] ANALYSE FONCTIONNELLE (4 ECTS)

UE resp : MARTEL Julia

Prerequisite (in french) :
Notions de topologie métrique (distance, norme, applications linéaires continues, complétude) et de calcul intégral (mesure de Lebesgue, théorèmes de Fubini, de Fatou, de Beppo-Levi; convergence dominée, convergence monotone).

Parcours : Mathématiques appliquées (MA)

Aims :

- Understand convexity in infinite-dimensional linear spaces and its applications to (continuous) linear forms.
- Understand completness in infinite-dimensional linear spaces and its applications to continuous linear spacess between Banach spaces.
- Understand various types of convergence.

Module 1 Analyse fonctionnelle 1

Module 2 Analyse fonctionnelle 2

ANALYSE FONCTIONNELLE 1

Content :

- Convexity in infinite dimension
- Duality. Riesz representation theorem for duality in Lp
- Hahn-Banach theorems

ANALYSE FONCTIONNELLE 2

Content :
Completeness. Baire's theorem.

- The Banach theorems (open map, closed graph, Banach-Alaoglu).
- Weak and *-weak convergence.

- Convex projection. Minimization of semi-continuous convex functionals.

[ANDO23] ANALYSE DE DONNÉES (4 ECTS)

UE resp : AMBROISE Christophe

Prerequisite (in french) :

- statistiques multivariées
- algèbre linéaire

Parcours : Mathématiques appliquées (MA)

Effectif : 70

Aims :

The lecture introduces the theory and practice of multivariate exploratory statistical analysis methods for processing and analyzing large data tables. In the field of machine learning, this type of analysis relates to unsupervised learning, the objective of which is to summarize, synthesize and visualize. The lecture is about understanding the models, the algorithms and knowing how to interpret the results.

[ARMA23] ARCHITECTURE MATÉRIELLE (4 ECTS)

UE resp : MOUILLERON Christophe

Prerequisite (in french) :
Programmation Impérative (requis), Programmation Fonctionnelle (conseillé), Assembleur et compilation (conseillé)

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL)

Effectif : 30

Aims :
In this course, we study the hardware structure inside of a computer and how it works. Firstly, using logic gates, we see how to build more and more advanced circuits, up to the design of a simple mini-processor. Secondly, we discuss several techniques used in modern processors (pipeline, branch prediction, memory hierarchy, SIMD) and see how this can be taken into account in order to improve the efficiency of some codes.

Content :

- Combinatorial logic circuits
- Arithmetic logic units
- Sequential circuits
- Design of a mini-processor using a simulator
- Pipeline, Instruction-level paralellism
- Memory hierarchy, Loop nest optimization
- Exploiting SIMD within a processor

[ARSE23] ARCHITECTURE D'UN SYSTÈME D'EXPLOITATION (4 ECTS)

UE resp : WIBER Gilles

Prerequisite (in french) : None

Parcours : Mathématiques appliquées (MA)

[ASCO23] ASSEMBLEUR ET COMPILATION (4 ECTS)

UE resp : BUREL Guillaume

Prerequisite (in french) :
Programmation impérative, programmation fonctionelle

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL)

Effectif : 70

Aims :
The binary code that is executed on a computer can be represented in a more readable way using a assembly language. This option presents the basis notions of assembly, and explain how to translate a program written in a high-level programming language into machine code thanks to compilation. Transforming a set of sources written in high-level languages into executable code while optimising them is a complex task that combines may steps.

The objective of this option is :

- to describe how the main abstractions of high-level languages are translated into machine code;
- to show the mechanism present in compilers. Furthermore, several mathematical techniques are introduced, that are useful in many computer topics (rewriting, fixed points, etc.);
- to present the tools that automate the first steps of compiling, and to show their efficiency through a project.

Content :

- Machine code and assembly langage;
- Assembly langage MIPS;
- Architecture of a compiler;
- Syntax analysis;
- Instruction selection;
- Control flow graph;
- Explicitation of calling conventions;
- Liveness analysis;
- Register allocation.

[DJVU23] DÉVELOPPEMENT DE JEUX VIDÉO 1 (4 ECTS)

UE resp : JEANNAS Vincent

Prerequisite (in french) :
Langage Objet
Projet info du S2

Parcours : Génie logiciel (GL),Interactions Numériques (IN)

Effectif : 32

Aims :
The main goal of this course is to have a glimpse of the Game Engines.
It shows how such Engines can be useful and their various aspects (rendering, physics, gameplay, animations, etc) on the basis of two main examples : Unity3D and Unreal Engine.
Acquired competences are then used to create a video game.
Evaluations are focused on technical aspects (and not artistic ones). The solutions proposed to the various technical issues, good practices and global code quality will be evaluated.

Content :
Component-based software engineering
Vector Calculus
Blueprints (Unreal)
Ray casting, colliders
Coroutines, animations
Teamwork
Notions of videogame production pipeline
Notions of game design

[GELO23] GÉNIE LOGICIEL (4 ECTS)

UE resp : ROUSSEL David

Prerequisite (in french) : None

Parcours : Génie logiciel (GL)

Effectif : 60

Aims :

The purpose of this teaching unit is to introduce students to the principles of Software Engineering and to train them in modeling with UML. The course will also provide an awareness of model-driven engineering.

At the end of this training, students will:

1. Know the contours of the field of software engineering
2. Master the concepts of UML structural and behavioral modeling
3. Know how to model an application in UML
4. Understand SysML and Requirements Management

Content :

The purpose of this teaching unit is to introduce students to the principles of Software Engineering and to train them in modeling with UML. The course will also provide an awareness of model-driven engineering.

At the end of this training, students will:

- Know the contours of the field of software engineering
- Master the concepts of UML structural and behavioral modeling
- Know how to model an application in UML
- Understand SysML and Requirements Management

[INPS23] INTRODUCTION À LA PROGRAMMATION SCIENTIFIQUE

(4 ECTS)

UE resp : DUBRAY Noel

Prerequisite (in french) :

* environnement linux (utilisateur)
* C++
* HTML / javascript
* algère linéaire

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 30

Aims :

This course aims at giving to the students a first experience of developing scientific HPC codes. To this end, a toolset will be presented and will be used by the students during two projects. This toolset includes developing tools, scientific libraries, debugging tools, post-processing tools, and some numerical optimization techniques.

Module 1 IPS-DEV

Module 2 IPS-PROD

IPS-DEV

IPS-PROD

[LFVL23] LANGAGES FORMELS, VALIDATION ET VÉRIFICATION DU LOGICIEL

(4 ECTS)

UE resp : DUBOIS Catherine

Prerequisite (in french) : None

Parcours : Génie logiciel (GL),Interactions Numériques (IN)

Aims :

This UE presents the fundamental concepts of formal languages and systems in the first part and introduces the techniques of testing and proof of programs in the second part.

Module 1 Langages et systèmes formels

Module 2 Validation et vérification du logiciel

LANGAGES ET SYSTÈMES FORMELS

Aims : Understand the problem of describing languages through enumerative processes (grammars), algebraic processes (rational systems) and recognition based processes (finite automata). Discover that there are languages that are not recognizable according to these processes. Know how Lex and Yacc work: techniques based on automata are indeed omnipresent in computer science. Build abstract syntax trees.

Content :

Context-free grammars, regular grammars and reductions, rational languages, finite state automata (deterministic, non-deterministic, minimal, pumping lemma).

Lexical analysis, syntactic analysis (top-down and bottom-up).

Abstract syntax trees.

VALIDATION ET VÉRIFICATION DU LOGICIEL

Aims : The purpose of this module is to acquire the basics of testing and formal proof techniques for the systematic verification and validation of computer programs and systems. This module presents fundamental contributions and practical application of some tools for testing and proving programs.

Content :

- Place of validation and verification in the software development cycle, objectives, overview of different techniques
- Functional testing
- Structural testing
- Contract-based specification
- Hoare logic, proof of programs
- Introduction to Junit, PathCrawler and the FramaC platform

[LODM23] LE LOGICIEL, DISPOSITIF MÉDICAL (4 ECTS)

UE resp : KHIDER Nassim

Prerequisite (in french) : None

Effectif : 30

Aims :

The objective of this course is to discover the field of the clinical trial and the medical device in particular the software, used in the field of health. To understand their classification according to their criticality, the constraints and the regulation for their validation. To know the certifying and regulating agencies (French and European)

[MERR23] MÉTHODE DE RÉGRESSION RÉGULARISÉE (4 ECTS)

UE resp : MOUGEOT Mathilde

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM),Mathématiques appliquées (MA)

Effectif : 70

Aims :
This course presents the theory and practice of regression models that are more sophisticated than the linear model, better suited to today's data, especially in the presence of high correlation and large data sizes. The MERR course in a first step for studying machine learning models. It introduces linear predictive models in the regression and classification framework : classical models as coefficient penalized models are studied

Module 1 MERR/ cours

Module 2 MERR/projet

MERR/ COURS

Aims : ordinary least square, linear model, linear models with constrains, course and practical sessions.

Content :
ordinary least square, linear model, linear models with constrains, course and practical sessions.

MERR/PROJET

Aims : Applications on the course and practical sessions on real data

Content :
Applications on the course and practical sessions on real data

[MOOC23] MOOC3 (4 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) : None

Aims :

The aim is that the students learn to learn by themselves with Massive Online Open Courses. For that the student chooses a technical subject related to ENSIIE and develop that with a MOOC.

[PIMA23] PROJET INFORMATIQUE ET MÉTHODES AGILES (4 ECTS)

UE resp : GAUTIER Jérôme

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL),Interactions Numériques (IN),Mathématiques appliquées (MA)

Aims :

The PIMA course aims to raise students' awareness of the concepts surrounding agile practices and in particular the Scrum workflow. The desired outcome is for students to acquire some of the know-how required to join an agile team.

Scrum offers an iterative approach by which the definition of the final product is progressively refined throughout the project.

PIMA aims at evaluating the students' ability to understand, implement, and internalize this approach.

The course consists of two half-day lectures followed by ten half-day lab sessions in which the class is split in two. Each student therefore only participates in five lab sessions.

The objective of the lab sessions is to apply Scrum to carry out a small-scale software project.

Students form teams of 6 to 8 people.
They may either choose a project from a list of proposed topics or propose one of their own.
Teams must go through five sprints during which they should be coordinating through daily meetings to develop the product increment described in the sprint backlog.
During a lab session, they will go through the different Scrum ceremonies: demo, retrospective, backlog grooming if needed, and finally sprint planning.

At the end of the course, students should know about agile teams, the different Scrum ceremonies and their goals, and the limitations of agile practices.

[PRAP23] PROGRAMMATION AVANCÉE ET PROJET (4 ECTS)

UE resp : TORRI Vincent

Prerequisite (in french) :
Programmation Impérative

Parcours : Mathématiques appliquées (MA)

[PRPA23] PROGRAMMATION PARALLÈLE DISTRIBUÉE (4 ECTS)

UE resp : JAEGER Julien

Prerequisite (in french) :
Programmation C/C++ nécessaire

Parcours : Calcul Intensif et Données Massives (CIDM)

Aims :
This UE focuses on distributed-memory parallel programming for High-Performance Computing (HPC). The courses and hands-on will present the Message Passing Interface (MPI) API and all its aspects such as the API, algorithms used in most MPI implementations, tricks and tips to produce an efficient MPI program.

Module 1 Introduction à MPI

Module 2 Programmation MPI avancée

INTRODUCTION À MPI

Aims : This module focuses on the basis of MPI programming

Content :

- Introduction to MPI
- Data exchange with point-to-point communications
- Data exchange with collective communications
- Data exchange with advanced collective communications
- Details and usage of derived datatypes
- Hands-on to use the concepts seen during lectures

PROGRAMMATION MPI AVANCÉE

Aims : This module focuses on more advanced features of MPI, such as reading/writing in memory (I/O) or Remote Memory Access (RMA) data exchange. This module introduces high-speed networks and the network topologies found in HPC supercomputers. This module also offers a few tips to produce an efficient MPI program.

Content :

- Parallel reading and writing of files with MPI-IO
- Data exchange with one-sided communications (RMA MPI)
- Introduction to high-speed networks
- Description of network topologies in HPC supercomputers
- Tricks and tips to have an efficient MPI program

- Hands-on to use concepts seen during lectures

[PRFO23] PROGRAMMATION FONCTIONNELLE (4 ECTS)

UE resp : FOREST Julien

Prerequisite (in french) :
Notions de base en programmation fonctionnelle :

- récursivité
- fonctions de premier ordre
- persistance
- type inductifs

Les apports théoriques du cours de programmation fonctionnelle de première année sont supposés acquis.

Parcours : Génie logiciel (GL)

[PRST23] PROCESSUS STOCHASTIQUES (4 ECTS)

UE resp : SAGNA Abass

Prerequisite (in french) :
Théorie des Probabilités

Parcours : Mathématiques appliquées (MA)

Effectif : 50

Aims :
We introduce in this lecture the fondamentals on (discrete) stochastic processes, in particular, martingales and Markov chain. It give to students the neccessary tools to follow some domains where these notions are applied like Mathematical Finance, Econometrics, etc.

[REOP23] RECHERCHE OPÉRATIONNELLE (4 ECTS)

UE resp : WATEL Dimitri

Prerequisite (in french) :
Graphes et optimisation dans les graphes, optimisation mathématique, probabilités, algorithmique, Programmation impérative, Programmation fonctionnelle

Parcours : Génie logiciel (GL),Mathématiques appliquées (MA)

Effectif : 100

Aims :
Operations research (OR) is a set of methods, models, algorithms and mathematical and computer science tools used to solve industrial problems, particuliarly **networks** (routing, wiring), **transportation** (people or products), **production** (assembly line, team management), **economical markets** (wallet optimization), ... In brief, it includes technical or economical choices a compagny must do. OR is then a **decision support system**. The main goal consists in understanding the problem (discuss with the person, the client who wants to solve the problem), secondly, model it with an OR problem (formalize the explanations of the client by removing every fuzzy or informal information and replacing the text by a mathematical model) and thirdly solve it using known algorithms and methods or variants of those methods.

OR is a huge area with three main fields : combinatorial problems, continuous optimization and probabilistic problems. The goal of the course is to teach the students into recognizing an OR problem and handling it. The course introduces the classical OR problems. Every problem is accurately detailed with some known methods or algorithms to solve it, and the proofs with which we can demonstrate the correctness of the methods. Note that the basics of shortest path problems and scheduling are already taught in the first year course *Graph Theory and Graph optimization* ; similarly Linear programming is taught in the course *Mathematical optimization*. All the subjects of the course are extended in the second-year and third-year courses *Operations research complements and tools*, *Optimization 1* and *Optimization 2*.

Content :
The course is split in three parts:

Combinartorial optimization

- Dynamic programming,
- Scheduling with contraints, Workshop and warehouse scheduling,
- Maximum flow problem, minimum cut,
- Branch and bound procedures,

Continuous optimization

- Primal methods : projected gradient and reduced gradient,

- Penalties and barrier methods,

Stochastic processes

- Markov process and Markov chains,
- Birth and death process, and queues.

[SERM23] SÉCURITÉ RÉSEAUX (4 ECTS)

UE resp : RIOBOO Renaud

Prerequisite (in french) :
Connaissances de base en réseau et en mathématiques

Parcours : Génie logiciel (GL),Interactions Numériques (IN)

Effectif : 30

Aims :
Understanding cryptographic algorithms, error correction and cryptographic protocols

[ECGE23] ECONOMIE-GESTION 3 (3 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) : None

Module 1 Droit civil et informatique

Module 2 Créativité et innovation

DROIT CIVIL ET INFORMATIQUE

CRÉATIVITÉ ET INNOVATION

[LVFH23] LANGUES VIVANTES ET FORMATION HUMAINE (3 ECTS)

UE resp : BOURARD Laurence

Prerequisite (in french) :

Maîtrise de la langue française (niveau B2 recommandé)

Niveau B1-B2 en anglais

Aims :

Improving proficiency in two foreign languages (including English).

Mastering the basics of communication in the business world

Module 1 LV1

Module 2 LV2

Module 3 La communication au service de l'entreprise

LV1

Aims : English skills for the global engineer/successful business interactions.

Improving language proficiency and reaching the B2 level of the CEFR or higher (Common European Framework of Reference for Languages)

Content :

Class discussions and tasks based on authentic audio and video recordings, current events and real-life contexts.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing.

Preparing for different certifying test formats - online and offline practice.

LV2

Aims : Being able to (better) communicate in one of the following foreign languages:

German, Chinese, Spanish, French, Italian, Japanese, Russian.

Content :

Class discussions and tasks are based on authentic and semi-authentic materials (audio/video recordings, news articles, textbooks). Topics and level of difficulty will vary according to students' language proficiency.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing, Learning about a foreign culture.

LA COMMUNICATION AU SERVICE DE L'ENTREPRISE

Aims : Introduction to corporate communication and business strategy

Understanding communication tools and channels, analyzing problems and challenges

Content :

- Corporate culture
- Corporate communication
- Business communication
- Digital communication

SEMESTER 4

Organisation. Student have to choose 6 technical teaching units (cf Figure 2): 1 teaching unit must be choosen in each column.

Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	Gr. 6	TC	TC
MESI24	AEDP24	MOST24	CAST24	INMF24	PRRE24	ECGE24	LVFH24
INAR24	IPBD24	GEDA24		CORO24	PRBI24		
SERP24	MFDL24	PRCV24	MOCA24	BIOI24	SESI24		
LAOA24	IMRA24	CRCO24	COON24	RVIG24	AUTO24		
READ24	PRSA24	LOCL24*	REDA24*	PABT24*	SYFP24*		
MEAA24		DJVD24	NUDS24		BLOC24		

Figure 2: Teaching unit of S4

Options (teaching units of each option)

- *Calcul Intensif et Données Massives* (CIDM) Resp. Pierre Dossantos-Uzarralde) : READ24, PABT24, LOCL24, SYFP24, REDA24, PRSA24/IPBD24
- *Génie logiciel* (GL) Resp Guillaume Burel : INAR24/LAOA24/REDA24/SERP24, PRCV24, GEDA24, CORO24/BIOI24, MFDL24, MOCA24, SESI24
- *Interactions Numériques* (IN) Resp. Guillaume Bouyer : LAOA24/READ24/INAR24, COON24, CRCO24, RVIG24, IMRA24, AUTO24/PRBI24
- *Mathématiques appliquées* (MA) Resp. Sergio Pulido Nino: MESI24/INAR24, MOST24, INMF24/CORO24, AEDP24/IPBD24, CAST24, PRRE24/AUTO24

Contents

[AEDP24] ANALYSE DES ÉQUATIONS AUX DÉRIVÉES PARTIELLES

(4 ECTS)

UE resp : TORRI Vincent

Prerequisite (in french) :
Programmation avancée et projet

Parcours : Mathématiques appliquées (MA)

Effectif : 32

[AUTO24] AUTOMATIQUE (4 ECTS)

UE resp : DAMM Gilney

Prerequisite (in french) : None

Parcours : Interactions Numériques (IN)

Aims :

Automatic Control is known as the hidden technology. Its objective is to design mathematical algorithms to make systems behave in a desired way, respecting constraints and fulfilling some optimality objectives. Systems can be physical like drones, SmartGrids, autonomous vehicles but also economic societal or biological. In this course it will be presented the main tools to design such control algorithms as well as virtual sensors, used to estimate system's most important unmeasurable variables.

Content :

Main topics are:

1. Dynamic models
2. Linear systems
3. Transfer function, poles and zeros, state variables, bloc diagram
4. Stability definitions
5. Controlability and observability
6. Control algorithms (state feedback, PID...)
7. State estimation (observers – virtual sensors)
8. Digital control: sampling, z transform, z transfer function, digital state space representations, pole placement, observers

[BIOI24] BIO-INFORMATIQUE (4 ECTS)

UE resp : TAHI Fariza

Prerequisite (in french) : None

Parcours : Génie logiciel (GL)

[BLOC24] BLOCKCHAIN (4 ECTS)

UE resp : DUMBRAVA Stefania

Prerequisite (in french) :
Bonnes compétences en programmation Java.

Parcours : Génie logiciel (GL)

Aims :
The pedagogical objective is acquiring basic knowledge concerning the technical principles behind distributed databases and the Blockchain technology, as well as its use in the creation of crypto-currencies and of "smart contracts". The unit serves as an introduction to the main blockchain development tools. The projects will consist of designing an application or a blockchain protocol, implementing it in Solidity or in Max, and presenting the final product.

Module 1 Blockchains classiques

Module 2 Blockchains de nouvelle génération

BLOCKCHAINS CLASSIQUES

Aims : Introduction to classical blockchains.

Content :
The unit will give a presentation of the following topics: introduction to Bitcoin (the structure of transactions, cryptographic primitives, the protocol), the basis of the Ethereum technology (le virtual machine and the execution of smart contracts), introduction to Smart Contract programming in Solidity and practical handling of a blockchain ("lightning channels" and "atomic swaps").

BLOCKCHAINS DE NOUVELLE GÉNÉRATION

Aims : Introduction to new generation blockchains.

Content :
The unit will give a presentation of the following topics: the basis of distributed systems (system models, communication primitives, the CAP theorem, consensus), Proof of Work blockchains and BFT consensus, multi-agent simulation for blockchain development, programming with the Max multi-agent simulator.

[CAST24] CALCUL STOCHASTIQUE (4 ECTS)

UE resp : KHARROUBI Idris

Prerequisite (in french) :
Probabilité, Processus stochastique

Parcours : Mathématiques appliquées (MA)

Effectif : 50

Content :

- Probability
- Brownian motion, stochastic calculus, Ito formula
- Martingale and Girsanov theorem
- Stochastic differentiel equation
- Black-Scholes model

[COON24] CONCEPTION D'UNE OEUVRE NUMÉRIQUE (4 ECTS)

UE resp : PICHON Auriane

Prerequisite (in french) :
Aucun

Parcours : Interactions Numériques (IN)

Effectif : 20

Aims :
Develop a real sensitivity to the various dynamics between functional and creative design of a project, by getting into manufacturing tools inspired by *maker* communities (digital and electronic devices, Arduino, typical fablab tools) to reinvent objects and their uses.

Module 1 Introduction : ressources créatives et techniques

Module 2 Réalisation d'un projet créatif

INTRODUCTION : RESSOURCES CRÉATIVES ET TECHNIQUES

Aims : Objective: to combine theoretical knowledge on alternative creative networks with technical discoveries on the basis of electronics.

Content :

- Introduction to *makers* networks, alternative practices of technologies
- Visits of cultural sites in the Ile-de-France region and / or exhibitions depending on current events, meetings with artists
- Electronics basis

RÉALISATION D'UN PROJET CRÉATIF

Aims : Objective: design a project inspired by the resources discussed in the first module, according to the theme given by the teacher and depending on the material available, and document the manufacturing process.

Content :

- Presentation and handling of Arduino technologies
- Design of a creative team project
- Document the process

[CORO24] COMPLÉMENTS ET OUTILS DE RECHERCHE OPÉRATIONNELLE

(4 ECTS)

UE resp : FAYE Alain

Prerequisite (in french) :

Graphe Semestre 1

Optimisation Semestre 2

Recherche Opérationnelle Semestre 3

Parcours : Génie logiciel (GL),Mathématiques appliquées (MA)

[CRCO24] CREATIVE CODING (4 ECTS)

UE resp : PICHON Auriane

Prerequisite (in french) :
Aucun

Parcours : Interactions Numériques (IN)

Effectif : 20

Aims :
Discover the artistic creative processes related to digital technology, develop a real sensitivity to the various dynamics between engineers and artists, and approach a more creative practice of computer tools.

Module 1 Introduction : ressources créatives et techniques

Module 2 Réalisation d'un projet créatif

INTRODUCTION : RESSOURCES CRÉATIVES ET TECHNIQUES

Aims : Objective: to combine theoretical knowledge on alternative creative networks with technical discoveries on the basis of electronics.

Content :

- Introduction to *makers* networks, alternative practices of technologies
- Visits of cultural sites in the Ile-de-France region and / or exhibitions depending on current events, meetings with artists
- Electronics basis

RÉALISATION D'UN PROJET CRÉATIF

Aims : Objective: design a project inspired by the resources discussed in the first module, according to the theme given by the teacher and depending on the material available, and document the manufacturing process.

Content :

- Presentation and handling of Arduino technologies
- Design of a creative team project
- Document the process

[DJVD24] DÉVELOPPEMENT DE JEUX VIDÉO 2 (4 ECTS)

UE resp : Y Vitera

Prerequisite (in french) :
- DJVU23 (ou connaissances équivalente d'Unity)

Parcours : Interactions Numériques (IN)

Effectif : 32

Aims :

The goal here is to go in depth into knowledge concerning Unity3D in order to allow the student to be able to develop a small scaled shippable game.

Advanced development tools included in the engine will be introduced in order to tackle optimisation issues which depend on plateform and time-to-market.

Content :
- Game design introduction
- Nested Prefab
- Advanced physics
- Considerations on UI/UX
- Video games market
- Cross platform development

[GEDA24] GESTION AVANCÉE DES DONNÉES (4 ECTS)

UE resp : DUMBRAVA Stefania

Prerequisite (in french) :
Conception de Bases de Données Relationnelles, semestre 1

Parcours : Interactions Numériques (IN)

Aims :
To organize and efficiently and reliably administer increasingly large, heterogeneous, and widely distributed data volumes (ranging from centralized Big Data to decentralized Edge Computing), it is essential to master the internal mechanisms implemented in large data servers.

The pedagogical objectives comprise of acquiring basic knowledge concerning: storage and indexing, query optimization, transaction protocols, security, consistency and data integrity, relational servers and NoSQL systems, as well as the functioning of graph databases (Neo4j) and their application to the analysis of large volumes of interconnected data.

Module 1 Gestion avancée des données relationnelles

Module 2 Bases de données graphes

GESTION AVANCÉE DES DONNÉES RELATIONNELLES

Aims : The objectives of the EU concern the acquisition of basic knowledge concerning: storage and indexing, query optimization, transaction protocols, security, consistency and integrity of data, as well as relational servers..

Content :
This module aims to provide students with the basic knowledge required to grasp the underlying principles behind data storage and indexing, query evaluation and optimization, as well as fault and attack tolerance. It introduces the concepts and algorithms implemented in large relational DBMSs (e.g., Oracle).

BASES DE DONNÉES GRAPHES

Aims : The objectives of this module consist of acquiring basic knowledge concerning the functioning of graph databases (e.g., Neo4j) and their application to the analysis of massive volumes of inter-connected data.

Content :
The module illustrates the functioning of graph database systems (e.g., Neo4j). These

systems are used to model and analyze large volumes of interconnected data and have various practical applications, such as the management of social networks, the design of recommendation systems in e-commerce, fraud detection in financial transaction graphs, as well as the development of knowledge graphs for the Semantic Web (i.e., Google's Knowledge Graph). The practicals, as well as the final project (to be carried out in groups), concern several of these use cases.

[IMRA24] IMAGES ET RÉALITÉ AUGMENTÉE (4 ECTS)

UE resp : ROUSSEL David

Prerequisite (in french) : None

Parcours : Interactions Numériques (IN)

Effectif : 32

Aims :

As part of the IN thematic course, the objective of this option is to present the different concepts and tools implemented in computer vision (2D and 3D), as well as the main applications. These different elements are then integrated into field of Augmented Reality (AR), the real / virtual registration is largely based on the extraction and recognition of image features. The paradigms used in AR to augment reality with virtual elements (virtual real continuum, architectures, augmentations and rendering) are then presented. All of these elements will allow students to master the processing chain used to build augmented reality applications.

Module 1 Vision Artificielle

Module 2 Réalité Augmentée

VISION ARTIFICIELLE

RÉALITÉ AUGMENTÉE

[INAR24] INTELLIGENCE ARTIFICIELLE (4 ECTS)

UE resp : DUBOIS Catherine

Prerequisite (in french) :
Logique des prédicats - Maitrise de OCaml et/ou de Java.

Parcours : Génie logiciel (GL)

Aims :
Artificial Intelligence has a triple objective: to understand the fundamental principles of intelligence, to simulate natural, and in particular human, cognition, and to solve difficult problems for which no reliable and efficient algorithms are known. This course presents some of the fundamental methods concerning the problem of knowledge representation and reasoning. We will thus approach heuristic methods, logical reasoning and collective intelligence, which will lead to the realization of practical exercises and projects.

Module 1 Résolution de problèmes

Module 2 Programmation Logique

Module 3 Intelligence Artificielle Distribuée

RÉSOLUTION DE PROBLÈMES

Aims : The purpose of this course is to introduce the foundations of Artificial Intelligence, by presenting the classical symbolic approaches to problem solving.

Content :

- Artificial Intelligence: objectives and history
- Problem solving
- Heuristic reasoning
- Algorithms for 2-player games
- Constraint solving

PROGRAMMATION LOGIQUE

Aims : The purpose of this course is to give an overview of logic programming and constraint logic programming.

Content :

- Presentation of logic programming with Prolog (from a logical and operational point of view)
- Constrained logic programming
- Illustration and practical use of the swi-prolog language
- Illustration and implementation of some notions introduced in the "Problem Solving" module

---

INTELLIGENCE ARTIFICIELLE DISTRIBUÉE

Aims : The purpose of this course is to present multi-agent systems and to give a theoretical and practical vision of them.

Content :

- Presentation of multi-agent systems, with a general introductory section justifying the need for systems operating in a collective and decentralized manner (with some examples of such systems),
- Quick introduction to agent-based simulation and application to reactive agent systems in which the focus is not on the individual intelligence of the agents but on the coordination mechanisms between agents and their strong ability to adapt to dynamic environments.

[INMF24] INSTRUMENTS ET MODÈLES FINANCIERS (4 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) :
Probabilité, Projet mathématique, Economie-Gestion 2, Processus stochastique

Parcours : Mathématiques appliquées (MA)

Effectif : 50

Module 1 Modèles discrets en finance

Module 2 Instruments financiers

MODÈLES DISCRETS EN FINANCE

Aims : This course introduce the mathematical finance with the discrete models. The first goal is to understand the discrete model, then no free lunch, complete market and risk neutral probability. The second goal is to price and hedge the derivatives in this framework.

Content :

- Discrete model
- No free lunch
- Risk neutral probability
- Pricing and hedging
- Binomial model and CRR
- Black Scholes model

INSTRUMENTS FINANCIERS

Aims : How we can use the financial products and why use that

Content :

- Bonds market
- Forwards

- Futures
- Swaps

[IPBD24] INGÉNIERIE DES PLATEFORMES BIG-DATA (4 ECTS)

UE resp : LEBRETON Olivier

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM),Mathématiques appliquées (MA)

Effectif : 30

Aims :

Exploiting the growing mass of data produced and collected every day requires the implementation of platforms capable of storing and manipulating this data to make it available to data scientists. The AIM of this EU is to present the different facets of the construction of such a platform: state of the art of technology, choice of equipment, sizing, deployment, exploitation. Through the handling of reference tools such as Hadoop, Spark, ElasticSearch and their ecosystems, students will be required to build a complete platform model that implements end-to-end data processing.

[LAOA24] LANGAGES OBJET AVANCÉS (4 ECTS)

UE resp : ROUSSEL David

Prerequisite (in french) :
Langages Objet en S2 validé

Parcours : Génie logiciel (GL)

Aims :
The objective of this option is to familiarize students with the advanced object concepts of containers, iterators (generalized pointers), algorithms (functors) and the decoupling of containers / algorithms with the help of iterators of the Standard Template Library or the QT framework, as well as the event paradigm of signals / slots in QT. The QT framework also integrates many aspects ranging from introspection (thanks to meta-objects) to graphical user interfaces in an MVC architecture. These concepts heavily used in current object development are then applied in the GUI part of QT with a project in order to apply seen in class.

Module 1 Concepts objets avancés

Module 2 Projet

CONCEPTS OBJETS AVANCÉS

PROJET

[LOCL24] LOGICIEL CLUSTER (4 ECTS)

UE resp : GREGOIRE Philippe

Prerequisite (in french) :

- *Notions réseau TCP/IP,*
- *Système d'exploitation Linux : concepts de l'OS et utilisation des commandes Linux.*

Parcours : Génie logiciel (GL)

Aims :

This course presents the hardware and software architecture of a High Performance Computing (HPC) cluster, detailing the operation of the most critical software components. The course will be based on the Linux operating system and the open source software most used in large data centers. At the end of the UE, the students will be able to design the architecture of a Linux cluster for the HPC, to plan its installation, to carry out its deployment and its integration in a computing center, and to set up the main services necessary for its production.

Content :

General presentation of the architecture of a supercomputer:

- Compute nodes (Xéon, ARM, accelerators, FPGA, etc.)
- Service nodes (Login, gateways)
- Post processing nodes
- Internal networks
- Challenges for the transition to exaflops.

Presentation of administration services and associated OpenSource software:

- automatic server installation systems (Kickstart, Cobbler, SystemImager, etc.) and associated protocols,
- control systems for servers (BMC, ipmi) and console/power management,
- log file management
- configuration management systems Puppet,
- time synchronization service (NTP),
- directory service(LDAP),

- domain name resolution service (DNS),
- open source software automatic compilation framework

Presentation of OpenSource Workload manager SLURM:

- batch and resource allocation systems,
- notions of resources, allocation algorithms,
- optimization of the selection of resources (topology, etc.) ,
- production management (priority, quality of service, accounting)

[MEAA24] MÉTHODE D'APPRENTISSAGE AUTOMATIQUE (4 ECTS)

UE resp : MILLET Christophe

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 30

[MESI24] MÉTHODES DE SIMULATION (4 ECTS)

UE resp : SAGNA Abass

Prerequisite (in french) :
Théorie des probabilités, Statistique Inférentielle

Parcours : Mathématiques appliquées (MA)

Effectif : 50

Aims :
The aim of this lecture is to introduce reference and advanced tools in stochastic sampling methods which are largely used in severals domains like in Statistics, in Quantitative Finance, in Insurance.

Content :
Simulation of random variables, Monte Carlo and variance reduction techniques, Monte Carlo method for Markov Chains (MCMC), the Hastings-Metropolis algorithm, the Gibbs algorithm, the simulated annealing. Sequential Monte Carlo techniques: importance sampling, sequential Monte Carlo, particle filtering.

[MFDL24] MÉTHODES FORMELLES POUR LE DÉVELOPPEMENT DE LOGICIELS SÛRS (4 ECTS)

UE resp : DUBOIS Catherine

Prerequisite (in french) :
logique

Parcours : Génie logiciel (GL)

Effectif : 30

Aims :
The objective is to introduce the use of formal methods for the development of safety and security-aware software.

The course introduces techniques for specifying, designing and implementing correct software by construction. The B/Event-B method and the successive refinement development method are presented. Refinement allows complicated or technical details to be left out of the early stages of development and introduced later in an incremental manner.

The course also focuses on security properties, such as integrity and confidentiality, and introduces the main access policies.

[MOCA24] MODÈLES DE CALCULS (4 ECTS)

UE resp : RIOBOO Renaud

Prerequisite (in french) :
Programmation, notions de mathématiques

Parcours : Génie logiciel (GL)

Aims :
Undestanding complexity and faisability of computer programs through Turing machines, Ulimited registers machines and lambda calculus

Module 1 Machines de Turing et Complexité

Module 2 Calculabilité

MACHINES DE TURING ET COMPLEXITÉ

CALCULABILITÉ

[MOST24] MODÉLISATION STATISTIQUE (4 ECTS)

UE resp : SZAFRANSKI Marie

Prerequisite (in french) :
Notions de statistiques, notions de programmation impérative, notions d'optimisation, notions d'analyse numérique.

Il est recommandé d'avoir suivi les cours d'analyse de données et de modèles de régression régularisés.

Parcours : Mathématiques appliquées (MA)

Effectif : 40

Aims :
This optional course presents a set of methods for studying relationships between observations on several variables (qualitative, quantitative or temporal) and the response of a random phenomenon, within the framework of supervised statistical learning on the one hand and chronological series on the other.

Module 1 Apprentissage automatique

Module 2 Séries temporelles

APPRENTISSAGE AUTOMATIQUE

Aims : Machine learning brings together a set of methods that aim to analyze, interpret, or even predict a phenomenon. The objective is to provide theoretical and practical elements of machine learning, within the framework of supervised classification especially.

Content :
The introduction to supervised machine learning is organized as follows:

- Methodology of machine learning: notions and evaluation of risk(s) and error(s) in machine learning,
- Methods: SVM, boosting and decision trees, Bayesian networks.

SÉRIES TEMPORELLES

Aims : This optional course deals with classical analysis and modeling methods of temporal data, ie indexed by time and having a dependency structure. We introduce smoothing, trend and seasonality estimation methods as well as estimation and prediction methods.

Content :

- Trend, seasonality, seasonal adjustment and smoothing,
- Stationary processes, ARMA model, Box-Jenkins approach and prediction.

[MOOC24] MOOC4 (4 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) : None

Aims :

The aim is that the students learn to learn by themselves with Massive Online Open Courses. For that the student chooses a technical subject related to ENSIIE and develop that with a MOOC.

[NUDS24] LE NUMÉRIQUE DANS LE DOMAINE DE LA SANTÉ (4 ECTS)

UE resp : KHIDER Nassim

Prerequisite (in french) : None

Parcours : Interactions Numériques (IN)

Effectif : 20

Aims :

Presentation of the main devices for diagnosis and treatment used in hospitals, with a focus on the software used to control and to process signals or data. You will discover the different departments of a hospital as well as the different jobs that you can get as an engineer.

[PABT24] PARALLÈLISME À BASE DE THREAD (4 ECTS)

UE resp : PERACHE Marc

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM)

Module 1 Modèle programmation Pthread

Module 2 Modèle programmation OpenMP

MODÈLE PROGRAMMATION PTHREAD

Aims : The objective of this module is to apprehend how to program explicitely using threads through the POSIX API, as well as the inner work of a user-thread library.

Content :

- Posix API
- Conception of user-thread libraries
- Debugging/profiling tools
- Debugging techniques in multithread context

Small project « around a user-thread library »

Bibliography
https://computing.llnl.gov/tutorials/pthreads/

MODÈLE PROGRAMMATION OPENMP

[PRCV24] PROGRAMMATION CONCURRENTE ET VÉRIFICATION

(4 ECTS)

UE resp : BUREL Guillaume

Prerequisite (in french) :
Programmation impérative; Introduction au Système d'Exploitation; Langages et systèmes formels.

Parcours : Génie logiciel (GL)

Effectif : 40

Aims :
This option introduces the concepts of concurrent programming and implements them through the use of threads. Besides, it is well known that it is hard to build an intuition on the correctness of concurrent programs, in particular concerning the absence of deadlocks or the access to ressources. To ensure this correctness, it is therefore needed to use formal verification techniques such as model checking.

Module 1 Concepts et Model checking

Module 2 Modèle programmation Pthread

CONCEPTS ET MODEL CHECKING

Aims : To understand the difficulties that arise with concurrent programming (critical sections, deadlocks), to master the standard tools to synchronize processes (semaphore) and to master verification techniques (model checking).

Content :

- Organization of computations in concurrent activities (processes or threads), difficulties due to shared variables, critical sections, deadlocks due to concurrent accesses; Evaluation
- Study of an exhaustive-verification environment.

MODÈLE PROGRAMMATION PTHREAD

Aims : The objective of this module is to apprehend how to program explicitely using threads through the POSIX API, as well as the inner work of a user-thread library.

Content :

- Posix API
- Conception of user-thread libraries
- Debugging/profiling tools
- Debugging techniques in multithread context

Small project « around a user-thread library »

Bibliography
https://computing.llnl.gov/tutorials/pthreads/

[PRBI24] PATTERN RECOGNITION AND BIOMETRICS (4 ECTS)

UE resp : GARCIA Sonia

Prerequisite (in french) : None

Parcours : Interactions Numériques (IN),Mathématiques appliquées (MA)

[PRRE24] PROJET RECHERCHE (4 ECTS)

UE resp : PULIDO NINO Sergio

Prerequisite (in french) : None

Parcours : Mathématiques appliquées (MA)

Aims :

- Introduce the students to dynamic and current topics in academic research, or to advanced subjects in computer science or mathematics.
- Tackle complex subjects with the tools of "academic research" and under the supervision of active researchers in the domain, in order to develop the skills of innovation and invention.

Through introductory classes, the students are introduced to a particular problem and to the conceptual and practical tools necessary to solve it. The students work in groups, do a literature review, and develop and implement solutions (completion of a program or software, writing of an analytical report, writing of a research article). The topics covered are mathematical and statistical modeling, simulation, and data science within the areas of engineering and finance.

[PRSA24] PROGRAMMATION SCIENTIFIQUE AVANCÉE (4 ECTS)

UE resp : DUBRAY Noel

Prerequisite (in french) :

- U.E. Introduction à la Programmation Scientifique
- environnement linux (utilisateur et administrateur)
- C++ et Python
- algèbre linéaire

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 30

Aims :

This course is a continuation of the IPS course. More developing tools will be presented, with a focus on the co-existence of C++ and Python in a given application. The project consists of the writing (from scratch) of a full-stack scientific code allowing to solve a linear algebra problem.

[READ24] RÉSEAUX IP ET ADMINISTRATION LAN (4 ECTS)

UE resp : TICHADOU Loris

Prerequisite (in french) :
INTRODUCTION AU SYSTÈME D 'EXPLOITATION
PROGRAMMATION WEB ET RÉSEAUX DE DONNÉES

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL),Interactions Numériques (IN)

Aims :

- Master the basic concepts of IP network operation and administration
- Master the basic concepts and tools of Linux system administration

Content :

- OSI model (in broad outline) CIDR: IP addressing, mask calculations, establishment of an addressing convention, static routing
- IPv6
- Basic tools (SSH, screen, tmux, notion of service, man...)
- Systemd
- (N)FS - Intro to systemD, intro to tp
- TCP, UDP, ICMP : uses and differences
- Firewalling : iptables, nftables, pf
- DHCP TFTP PXE
- HTTP / Apache/nginx
- firewalling, tcpdump, wireshark
- Ansible
- Network partitioning: VLAN, VRF + Network loops, broadcast storm and Spanning Tree Protocol
- Advanced routing: routing protocols (OSPF, ISIS, BGP)
- VPN (OpenVPN)

[REDA24] RÉSEAUX POUR DATACENTER/HPC (4 ECTS)

UE resp : GROS Damien

Prerequisite (in french) :

- Les bases du réseau : le modèle OSI, comprendre et savoir expliquer le service rendu par chaque couche. TCP/IP. administration réseau
- les bases de l'administration système
- utilisation du cluster (connexion, pcocc)

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL),Interactions Numériques (IN)

Module 1 Achitecture des réseaux Datacentre/HPC

Module 2 Spécificités des réseaux HPC

ACHITECTURE DES RÉSEAUX DATACENTRE/HPC

Aims : Describe the solutions provided by the main constructors and explain basic and evolved architectures for Datacenter and HPC networks.

Administrate an Infiniband network

Know the common technologies used in the Datacenters network.

Admnistrate advanced TCP/IP network.

Understand, use and administrate Software Defined Network.

Understand, use and administrate VXLAN.

SPÉCIFICITÉS DES RÉSEAUX HPC

Aims : Describe what is an interconnection network.
Explain the process of switching in HPC network
Explain the process of routing in HPC network
Explain how to guaranty the network performances : latency, bandwidth, etc.

Explain the characteristics of each main topology
Explain the influence of the placement inside the topology on the job performances.

[RVIG24] RÉALITÉ VIRTUELLE ET INFORMATIQUE GRAPHIQUE

(4 ECTS)

UE resp : BOUYER Guillaume

Prerequisite (in french) :
Maitrise des concepts de Programmation Objet (LAOB12 ou équivalent)

Connaissance du moteur de jeu Unity (DJVU23 ou équivalent)

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL),Interactions Numériques (IN)

Effectif : 32

Aims :
As part of the IN major: know what Virtual Reality applications are, what they are used for and how to make them, program visual rendering and 3D interactions in an application.

Module 1 Réalité Virtuelle

Module 2 Informatique Graphique

RÉALITÉ VIRTUELLE

Aims : Virtual Reality allows users to interact in a natural and immersive way in 3D digital environments. The module presents the technological and theoretical foundations, as well as the methods for the design of useful and usable 3D applications and interactions.

These concepts are applied in a team project: analysis of the current landscape, formal design of the application, realization in Unity with VR interfaces (cameras, headsets...), tests and presentation.

Content :

- Lecture 6 sessions
  - Basic definitions, history and applications of VR,
  - Sensory-motor channels; visual, audio, haptic and control interfaces; sensors,
  - Methods for designing a VR application and 3D interaction techniques
- Project 10 sessions
  - Hands-on practice with the tools,
  - Analysis of existing work

- Design of interactions (user-centered),
- Construction and animation of the virtual environment (scene graph, cameras, lights, etc.),
- Programming of interactions (selection, manipulation, navigation, control) and feedback,
- Testing,
- Presentation.

INFORMATIQUE GRAPHIQUE

Aims : Review the basics of computer graphics. Implement a scene graph using recent CG techniques (shaders, etc.)

Content :

- Graphic Pipeline
- Geometric mathematics for CG
- Scene graph,
- 3D Modeling
- Shaders

[SERP24] SÉCURITÉ DES RÉSEAUX ET DES PROTOCOLES (4 ECTS)

UE resp : MALTERRE Pascal

Prerequisite (in french) :
Notions de réseaux, systèmes informatiques, cryptographie et programmation.

Parcours : Calcul Intensif et Données Massives (CIDM),Génie logiciel (GL),Interactions Numériques (IN)

[SESI24] SÉCURITÉ DES SYSTÈMES D'INFORMATION (4 ECTS)

UE resp : MONTIBUS Ayfer-marie

Prerequisite (in french) :

Notions de systèmes informatiques, de programmation impérative, de bases de données et de sécurité réseau et middleware.

Parcours : Génie logiciel (GL)

Effectif : 30

Aims :

Security of information systems can be found in many IT fields. This module provides the fundamentals of security of information systems, and presents the main principles of cybersecurity (in depth defense, least privilege, cybersecurity awareness), its organisationnal aspects, the different fields in which can be found cybersecurity, the most frequents vulnerabilities, the risks and the existing security needs.

[SYFP24] SYSTÈMES DE FICHIERS PARALLÈLES (4 ECTS)

UE resp : LAFOUCRIERE Jacques-charles

Prerequisite (in french) :
Utilisation basique du shell Unix et programation C

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 15

Aims :
This lesson presents the different architectures of parallel file systems and their differences from distributed file systems. It also presents the technologies that will make it possible to build the systems of the future. At the end of the EU, students will be able to choose and configure an SFP that meets the needs of an HPC cluster. The course will use different file systems (Lustre, GPFS, pNFS and HadoopFS) in order to put forward the general concepts of data management within large computing and data processing centers.

Content :
[The module consists of 15 lessons and 8 practical works. The subjects covered during the courses are:

- data management within data centers
- distributed systems
- the concepts of a parallel file system (SFP) and client / server SFPs (Luster)
- security within the SFP
- the life of the data within an SFP
- SAN-type SFPs (GPFS)
- standard type SFPs (pNFS)
- fault tolerance within an SFP
- hadoop
- the future of SFPs

[ECGE24] ECONOMIE-GESTION 4 (3 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) :
Economie-Gestion 3

Module 1 Challenge entreprendre

Module 2 Savoir manager

Module 3 Impact environnemental du numérique

CHALLENGE ENTREPRENDRE

SAVOIR MANAGER

IMPACT ENVIRONNEMENTAL DU NUMÉRIQUE

[LVFH24] LANGUES VIVANTES ET FORMATION HUMAINE (3 ECTS)

UE resp : BOURARD Laurence

Prerequisite (in french) :

Maîtrise de la langue française (niveau B2 recommandé)

B1-B2 en anglais

Aims :

Improving proficiency in two foreign languages (including English).

Mastering the basics of communication in the business world

Module 1 LV1

Module 2 LV2

Module 3 La communication au service de l'étudiant

LV1

Aims : English skills for the global engineer/successful business interactions.

Improving language proficiency and reaching the B2 level of the CEFR or higher (Common European Framework of Reference for Languages)

Content :

Class discussions and tasks based on authentic audio and video recordings, current events and real-life contexts.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing.

Preparing for different certifying test formats - online and offline practice.

LV2

Aims : Being able to (better) communicate in one of the following foreign languages:

German, Chinese, Spanish, French, Italian, Japanese, Russian.

Content :

Class discussions and tasks are based on authentic and semi-authentic materials (audio/video recordings, news articles, textbooks). Topics and level of difficulty will vary according to students' language proficiency.

Reading (written comprehension), Listening (oral comprehension), Presenting, Debating, Writing, Learning about a foreign culture.

LA COMMUNICATION AU SERVICE DE L'ÉTUDIANT

Aims : Introduction to corporate communication and business strategy

Understanding communication tools and channels, analyzing problems and challenges

Content :

- Communication strategy
- Digital communication strategy
- Communication plan and tools
- Corporate e-reputation and personal branding

SEMESTERS 5 AND 6

SEMESTER 5

Semester 5 extends options of semester 3 and 4. The students follow 5 technical teaching units (at most one in each column cf Figure 3) and 2 non technical teaching units (TCJE35 and TCEFH35).

Organisation.

Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	Gr. 6	TC	TC
MOSC35	INRF35	MALE35	MOSA35	MENF35			
MORE35	DMIA35	INCA35	SYIR35				
GIIG35		PRRU35	PRRD35		SECD35	TCJE35	TCEF35
PYDS35	GEPA35	NTOE35	MANA35	OPTU35	OPTD35		
MERR35	VICC35	COAV35		SIGI35			

Figure 3: Teaching units of S5

Options (teaching units of each option)

- *Calcul Intensif et Données Massives* (CIDM) Resp. Pierre Dossantos-Uzarralde) : PYDS35/MERR35/COAV35, MALE35, VICC35, SIGI35, MANA35/MOSA35
- *Génie logiciel* (GL) Resp Guillaume Burel : GIIG35, PRRU35, PRRD35, OPTU35, OPTD35/SECD35
- *Jeu Vidéo et Interactions Numériques* (JIN - en partenariat avec TSP) Resp. Guillaume Bouyer : MORE35, DMIA35, INCA35, SYIR35
- *Mathématiques appliquées* (MA) Resp. Sergio Pulido Nino: MOSC35/PYDS35, MENF35, MOSA35, MALE35, INRF35
- *Organisation des entreprises* (OE): GEPA35, NTOE35, MANA35, OPTU35, OPTD35, PYDS35

Contents

[COAV35] COMPILATION AVANCÉE (5 ECTS)

UE resp : CARRIBAULT Patrick

Prerequisite (in french) :
Programmation informatique (type C/C++)

Parcours : Calcul Intensif et Données Massives (CIDM)

[DMIA35] DÉVELOPPEMENT MOBILE ET INTELLIGENCE ARTIFICIELLE

(5 ECTS)

UE resp : BOUYER Guillaume

Prerequisite (in french) :
Programmation Orientée Objet
Programmation web

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 40

Aims :
At the end of the module students will be able to :

- Know the specificities of mobile development and develop a mobile application
- Know the concepts and tools to understand the notions of interacting agents and agent-based systems.

Module 1 Développement Mobile

Module 2 Agents intelligents interagissant

DÉVELOPPEMENT MOBILE

Aims : At the end of the module students will be able to :

- Know the specificities of mobile development
- Develop a mobile application

Content :

- Discovery of Kotlin and Android Studio, compilation of a basic App on virtual and real device, debugging and profiling tools
- Implementation of a RecyclerView
- Querying a remote API
- Sending data to an API, permissions and background tasks
- Adding functionality

AGENTS INTELLIGENTS INTERAGISSANT

Aims : The general objective of the course is to provide the concepts and tools to understand the notions of interacting agents and agent-based systems. The notion of agent will be approached in a very broad way, with the presentation of both "cognitive" and "reactive" models.

We will focus on conversational agents by presenting models of representation, reasoning and communication that allow so-called "intelligent" agents to interact directly with the player. We will also study agents inspired by socio-biology by presenting the behavioural models that allow the simulation of autonomous environments populated by active entities around the player. Some notions of learning associated with these different agent architectures will also be presented.

Content :

- Simulation (to model and simulate any active entity [human, robot, animal, environment...] in a game)
- Agent architectures (reactive, cognitive, hybrid)
- Conversational agents (agent languages, modal logics, interaction protocols, negotiation)
- Group behaviour (flocking models, crowd simulation, etc.)
- Project using an agent-based modelling and simulation platform to illustrate in a concrete way the concepts discussed in the course.

[GEPA35] GESTION DE PROJET AVANCÉE (5 ECTS)

UE resp : CONNÉ Jean-françois

Prerequisite (in french) :
Savoir manager

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 40

[GIIG35] GREEN IT ET IT FOR GREEN (5 ECTS)

UE resp : LIGOZAT Anne-Laure

Prerequisite (in french) : None

Parcours : Interactions Numériques (IN)

Effectif : 40

Aims :
This module aims to present solutions that can be implemented in companies and organizations to reduce the environmental impact of ICT (GreenIT part), as well as to show the possible uses of ICT for environmentally useful applications, such as climate simulation (IT for Green part).

Module 1 GreenIT

Module 2 IT for Green

GREENIT

Aims : This module aims to present solutions that can be implemented in companies and organizations to reduce the environmental impact of ICT.

Content :
The lessons of this module will address the notions of digital sobriety, systemy, and enterprise architecture. These notions will be put into practice in case studies.

IT FOR GREEN

Aims : This module aims to show the possible uses of ICT for environmentally useful applications, such as climate simulation or energy consumption optimization.

[INCA35] INTERACTIONS ET CAPTEURS (5 ECTS)

UE resp : BOUYER Guillaume

Prerequisite (in french) :

Programmation objet (bonne pratique)

Moteur de jeu « Unity » (bonne pratique)

Infographie et traitement d'images (notions)

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 32

Aims :

Understand the functioning of man-machine interfaces (keyboard, mouse, joystick, body sensors), know how to design and program interactions adapted to the context and users.

Understand the different methods and algorithms of perception, reconstruction and interaction with the real environment in an augmented reality context.

Module 1 Interactions humains-systèmes

Module 2 Vision 3D pour la Réalité Augmentée

INTERACTIONS HUMAINS-SYSTÈMES

Aims : At the end of the module, students will be able to :

- explain the expected functionalities of a human-computer interface management system
- use the Unity/C# game engine on an interactive project
- program a character control component for a 2D platform game, describe and implement feedbacks and audit the result

Content :

- Interfacing Human-Games and Human-Game Engines
- Notions of user experience (UX), design and evaluation of human-machine interactions
- Project: controller interactions with a platform game character and feedbacks

VISION 3D POUR LA RÉALITÉ AUGMENTÉE

Aims : At the end of the module, students are able to:

- Describe the different methods and algorithms for perception, reconstruction and interaction with the real environment in an augmented reality context.

Content :

- Augmented Reality issues (real time, registration, tracking, etc.)
- Modeling and calibration of sensors (camera, Kinect, etc.)
- Pose calculation
- SLAM

[INRF35] INSTRUMENTS ET RISQUES FINANCIERS (5 ECTS)

UE resp : LY VATH Vathana

Prerequisite (in french) :
Probabilités, Instruments et modèles financiers

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 30

Aims :
This course introduces the basics of options and offers a practical approach to equity derivatives, as they are used in trading floors. The objective is thus to strengthen students' knowledge through a practical approach to financial markets.

Module 1 Couverture et gestion des risques

Module 2 Instruments financiers 2

COUVERTURE ET GESTION DES RISQUES

Aims : This course introduces the basics of options and offers a practical approach to equity derivatives, as they are used in trading floors.

Content :

- Interest rate risk management
- Actuarial rates, zero coupon rate and forward rate
- Definitions and valuation of interest rate instruments
- Construction of the ZC yield curve, Construction of a bi-curve
- Actuarial risk analysis tools
- Optional risk coverage and management
- Reminder of the main valuation models
- Dynamic management of optional risks
- Typology of strategies implemented
- Example / Risk management of a volatility fund

INSTRUMENTS FINANCIERS 2

Aims : Strengthen students' knowledge through a practical approach to financial markets

Content :

- Trading mechanism of financial instruments
- Dynamics of price construction and different types of arbitrage in the markets

- Manipulation of financial data from a database
- Realisation of vanilla options price, and implied volatility calculator

- Evaluation of an investment strategy - Backtest of systematic strategies

[MALE35] MACHINE LEARNING (5 ECTS)

UE resp : MOUGEOT Mathilde

Prerequisite (in french) :
Modèles de regression géneralisés. Modèles linéaires pénalisés. Notion d'analyse de données.

Parcours : Calcul Intensif et Données Massives (CIDM),Mathématiques appliquées (MA)

Effectif : 60

Aims :
Data exploitation is now a major challenge in many fields such as industry, finance, society... This course will present the theoretical foundations as well as the practical application of machine learning models commonly used in regression and supervised classification. Dimension reduction and quantification methods will also be studied.methods: parametric models (bayes, ADL, QDL,..), non-parametric models (KNN, decision trees,..), ensemble methods (bagging, random forest, boosting). Dimension reduction methods (functional PCA, Gaussian mixtures, Spectral clustering, Kmeans,...). Performance metrics. ROC curves.

Module 1 MAL/ predictive models

Module 2 MAL/unsupervised models

MAL/ PREDICTIVE MODELS

MAL/UNSUPERVISED MODELS

[MANA35] MANAGEMENT (5 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) :
Savoir manager

Parcours : Génie logiciel (GL)

[MENF35] MÉTHODES NUMÉRIQUES POUR LA FINANCE (5 ECTS)

UE resp : MENOZZI Stéphane

Prerequisite (in french) :
Probabilités du niveau d'un bon master 1. Notions de finances telles qu'apportées par le cours "Financial Markets and Actuarial Finance" du M2QF. et C++ et VBA telles qu'apportées par le cours "Programming" du M2QF.

Parcours : Mathématiques appliquées (MA)

Aims :
The course bears on the numerical analysis of financial derivatives. The objectives are:

1. Learning the basic tools in stochastic processes and stochastic analysis, with a focus on the Markov and martingale properties, in discrete then in continuous time,
2. Learning how to derive a pricing equation based on the probabilistic formulation of a model, possibly with stochastic volatility and/or jumps,
3. Learning how to implement a finite differences theta-scheme or a tree pricing scheme,
4. Learning Monte Carlo pricing and Greeking schemes: basic principles and variance reduction techniques, first in a set-up of random variables or vectors, then in a dynamic set-up of stochastic processes,
5. Learning how to choose the best numerical scheme for a given problem,
6. Mastering various programming languages for implementing all the above.

Bibliography:

- Main:
  - Crépey, S., Financial Modeling (Springer, 2013), chapters 1 à 9.
- Others:
  - Lamberton, D. and Lapeyre P., Introduction to Stochastic Calculus Applied to Finance. Chapman & Hall, 2 revised edition, 2007.
  - Hull, J., Options, Futures, and Other Derivative Securities, Prentice-Hall, last edition.
  - Glasserman P., Monte Carlo Methods in Financial Engineering, Springer, 2004.
  - Shreve, S.: Stochastic Calculus for Finance II: Continuous—Time Models, Springer, 2004 or later.

Content :

1. Stochastic analysis prerequisites

- Markov processes and martingales in discrete time
- Markov processes and martingales in continuous time
- Stochastic integration, Itô formula (for diffusions and processes with finite activity jump), stochastic differential equations, Girsanov theorem

2. Pricing models
   - Black-Scholes and Dupire; realized, implied, and local volatilities
   - Stochastic volatility (Heston), jumps (Merton 'jump-to-ruin' vs. Gaussian return jump size models)
   - Fourier pricing of vanilla options in affine jump diffusive models
3. Finite differences pricing schemes
   - $heta$-schemes for pricing equations in diffusive models
   - Convergence analysis. Stability and convergence: Lax equivalence principle (European options) / Barles and Souganidis theorem (American options and other nonlinear pricing problems). Order of consistency and convergence rates.
   - Localization and boundary conditions.
   - Exact solution by the Thomas algorithm for univariate tridiagonal problems
   - Iterative solvers
   - ADI schemes for multivariate problems
   - Recovering Greeks
   - Splitting schemes for American options
   - Adding jumps (integro-differential equations)
4. Monte Carlo Simulation pricing schemes
   - Foundations: law of large numbers and central limit theorem.
   - Standard (pseudo) Monte Carlo estimator, confidence interval and graph of convergence
   - Simulation of univariate random variables: inverse method; uniform, exponential and Gaussian random variables.
   - Simulation of random vectors: rejection-acceptance method; Gaussian random pairs (Box-Müller and Marsaglia methods); Gaussian random vectors (via Cholesky and spectral decompositions).
   - Variance reduction: antithetic variables, control variates,importance sampling,efficiency criterion.
   - Quasi-Monte Carlo and hybrid pseudo / quasi Monte Carlo schemes, bridge techniques
   - Greeking by Monte Carlo: Flow versus density differentiation (Malliavin) techniques
   - 8 Time-discretization of processes and Monte Carlo for processes
5. IV Markov chain pricing schemes
   - Fully-discrete Markov chain models
   - Dynamic programming tree pricing schemes
   - Convergence analysis: Kushner's theorem
   - Examples: Cox-Ross-Rubinstein binomial tree; Kamrad-Ritchken trinomial tree
   - Synthesis and performance comparison: Monte Carlo vs. PDE vs. tree pricing schemes.

- Hybrid forward simulation / backward pricing schemes for American options: value vs. policy iteration (Tsitsiklis and VanRoy vs. Longstaff and Schwartz)

6. Pricing path dependent of options
   - First generation exotic options: lookback, barrier, and Asian options
   - Second generation exotic options: forward-starting and cliquet options, volatility derivatives
7. Model calibration techniques
   - The ill-posed inverse calibration problem
   - Tikhonov regularization
   - Non-convex optimisation techniques : gradient methods vs. gradient-free, genetic algorithms.
   - Case studies on equity (local vol), interest-rate (multi-curve models), and credit portfolio derivatives (common shock model)

[MERR35] MÉTHODE DE RÉGRESSION RÉGULARISÉE (5 ECTS)

UE resp : MOUGEOT Mathilde

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM),Mathématiques appliquées (MA)

Effectif : 70

Aims :
This course presents the theory and practice of regression models that are more sophisticated than the linear model, better suited to today's data, especially in the presence of high correlation and large data sizes. The MERR course in a first step for studying machine learning models. It introduces linear predictive models in the regression and classification framework : classical models as coefficient penalized models are studied

Module 1 MERR/ cours

Module 2 MERR/projet

MERR/ COURS

Aims : ordinary least square, linear model, linear models with constrains, course and practical sessions.

Content :
ordinary least square, linear model, linear models with constrains, course and practical sessions.

MERR/PROJET

Aims : Applications on the course and practical sessions on real data

Content :
Applications on the course and practical sessions on real data

[MOOC35] MOOC5 (4 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) : None

Aims :

The aim is that the students learn to learn by themselves with Massive Online Open Courses. For that the student chooses a technical subject related to ENSIIE and develop that with a MOOC.

[MORE35] MODÉLISATION ET RENDU (5 ECTS)

UE resp : ROUSSEL David

Prerequisite (in french) :

- Programmation objet (bonne pratique)
- Infographie et traitement d'images (notions)

Parcours : Interactions Numériques (IN)

Effectif : 32

Aims :

- Understand how the graphics rendering pipeline works by programming the pipeline with OpenGL.
- Understand the theoretical basis for solving simple problems, identify, formalise and decompose complex problems in order to research and adapt existing solutions.
- Experiment with modelling tools using Blender software.

Module 1 Rendu visuel temps réel

Module 2 Modélisation et algorithmique géométrique 3D

Module 3 Modeleur 3D - Blender

RENDU VISUEL TEMPS RÉEL

Aims : At the end of the module students will be able to :

- implement the basic aspects of an OpenGL-based renderer
- analyse the skeleton of a game
- experiment with interaction using conventional devices (keyboard, mouse)

Content :

- 1 course on the fundamentals of the Graphics Pipeline

- 3 practical sessions for experimenting with OpenGL rendering, object loading, camera management, materials and textures, animation, interaction and optimisation
- 2 practical sessions for the realization of a game in OpenGL

MODÉLISATION ET ALGORITHMIQUE GÉOMÉTRIQUE 3D

Aims : At the end of the module students will be able to :

- exploit the theoretical aspects of 3D modelling

Content :

- The description, organisation and construction of scenes and the geometric elements composing them (quaternion, projections and homogeneous coordinates, implicit surfaces and Boolean operators, blob, recursion...).
- Boundary representations: polygons, polyhedra and triangulations (Euler relation, HDS, BSPTree, bounding volumes, Minkowski sum...),
- The basics of geometric algorithms and their applications in video games (D&C, KDtree, Delaunay & Voronoi...).

MODELEUR 3D - BLENDER

Aims : At the end of the module students will be able to :

- use a 3D modeler (Blender)

Content :

- Hard Surface Modeling
- Non Destructive Modeling (modifiers : sub-surf, arrays, bevels, ...)
- Animation (Shape Keys, Rigging, Dynamic Painting)
- Physics

[MOSA35] MODÉLISATION STATISTIQUE AVANCÉE (5 ECTS)

UE resp : CHARANTONIS Anastase

Prerequisite (in french) :
Le module Machine Learning a les prérequis suivants:

Le Module Deep Learning considère que vous avez suivi le cours de Méthodes de Régression Régularisées, ou que vous avez les bases de la régression linéaire et des pénalisations L1 & L2. Les TPs sont sous python3, en utilisant principalement la librairie keras. Il n'y aura pas de session pour apprendre python: préparez vous en avance en utilisant des tutos sur python et numpy et en ayant un cheat sheet. sous la main.
Si vous comptez utiliser vos propres pcs, assurez vous de vous mêmes que vous avez installé python et que vous pouvez faire tourner des jupyter notebooks.
Il seront aussi accessibles via l'utilitaire gratuit https://colab.research.google.com/ et vous pourriez utiliser les ordinateurs de l'école.

Parcours : Calcul Intensif et Données Massives (CIDM),Mathématiques appliquées (MA)

Effectif : 40

Aims :
The MOSA course consists of two modules: one on machine learning and one on deep learning and as such aims at familiarizing students with the essentials of data science.

Module 1 Apprentissage non-supervisé

Module 2 Deep Learning

APPRENTISSAGE NON-SUPERVISÉ

Aims : Unsupervised learning methods are today extremely used in many data science applications. For example, unsupervised learning is commonly used for segmentation in marketing applications.

Content :

- Model based clustering methods.
- K-means.
- Spectral clustering.
- Methods for computing the number of clusters (penalisation, Between/Within variances, silhouettes)

DEEP LEARNING

Aims : Deep learning structures have been at the source of the recent Data Science revolution. In this course we will learn the basic architectures that allow performing deep learning analysis.

Content :

We will present the basics of machine learning, and introduce the Perceptron algorithm. We will then focus on the Multi-layer perceptron, the backpropagation learning algorithm, the different activation functions and their benefits, the advantages of regularizations and present and apply recurrent neural networks as well as convolutional neural networks.

The lesson will require you to follow the install procedure presented here: https://github.com/brajard/nn/blob/master/INSTALL.md

To follow this course effectively, you will need to bring your own computer and have installed those materials.

[MOSC35] MODÉLISATION STOCHASTIQUE ET CONTRÔLE (5 ECTS)

UE resp : KAMTA Stéphane

Prerequisite (in french) :
Processus stochastique, Calcul stochastique, Instruments et modèles financiers

Parcours : Mathématiques appliquées (MA)

Effectif : 40

Aims :
Use stochastic calculus to model the interest rates and use that in stochastic control

Module 1 Modèles de courbes de taux

Module 2 Contrôle stochastique

MODÈLES DE COURBES DE TAUX

Aims : Understand the mathematics tools to model the interest rates and price the options

Content :
Model with one factor : Vasisek, Cox-Ingersoll-Ross, Heath-Jarrow-Morton

Pricing of options, zero coupon bonds

Forward probability

LIBOR

CONTRÔLE STOCHASTIQUE

Aims : Understand a stochastic control problem.

Know the classical methods to solve that.

Solve some toys model

Content :
Stochastic control in discrete model:

- American option and Snell envelope

- Duality method

Optimal stopping in continuous time with american option

- infinity maturity
- finite maturity

[NTOE35] NOUVELLES TECHNOLOGIES ET ORGANISATION DES ENTREPRISES

(5 ECTS)

UE resp : MUSET Catherine

Prerequisite (in french) : None

Parcours : Organisation des Entreprises (OE)

[OPTD35] OPTIMISATION 2 (5 ECTS)

UE resp : WATEL Dimitri

Prerequisite (in french) :
Théorie des graphes, Optimisation mathématiques, Recherche opérationnelle, Compléments et outils de recherche opérationnelle, Modèles de calcul et Optimisation 1 recommandées

Parcours : Génie logiciel (GL),Organisation des Entreprises (OE)

Effectif : 30

Aims :
Modern OR techniques can be applied to many fields. The courses introduce classical applicationsof those techniques, exercise the students so that they are able to use their knowledge to solve a problem ; and introduce algorithms used to quickly solve OR problems with linear programs.

Module 1 Conception et optimisation des réseaux

Module 2 Étude de cas

Module 3 Méthodes polyédriques

CONCEPTION ET OPTIMISATION DES RÉSEAUX

Aims : This course focus on designing and optimizing networks (location problem, sizing problems, routing problems). Those problems are usually hards and appears in many fields (computer science, telecommunication, ...).

Content :
The program contains exact methods to solve the problems with mathematical programming, good formulations, relaxations ... ; and high quality (but suboptimal) solutions computed by heuristics (constructive heuristics, local search, meta-heuristics, ...).

ÉTUDE DE CAS

Aims : This course exercises the students in order to complete successfully an optimization project.

Content :
formulation of the problem, complexity, mathematical model, solving the problem (exact

method, linear programming), evaluation of the algorithms, implementing the main operations research methods (mathematical programming, branch and bound, meta-heuristics, ...) and using optimization software. Distinct subjects are proposed every year to the students.

MÉTHODES POLYÉDRIQUES

Aims : Build an effective model for a combinatorial optimization problem. Such problems may be modeled by integer linear programs. In order to solve them efficiently, it is necessary to refine the model, using, for instance, valid inequalities.

Content :

Valid inequalities and methods to obtain them : Chvatal-Gomory cuts, disjunctive inequalities, valid inequalities with mixed variables, facets, cut algorithms, separation problems, benders cuts.

[OPTU35] OPTIMISATION 1 (5 ECTS)

UE resp : WATEL Dimitri

Prerequisite (in french) :
Théorie des graphes, Optimisation mathématiques, Recherche opérationnelle, Compléments et outils de recherche opérationnelle et Modèles de calcul recommandées

Parcours : Mathématiques appliquées (MA)

Effectif : 30

Aims :
Teach the students to the last necessary tools to solve a fundamental or applied optimization problem. In order to be specialized in the OR field, it is strongly advised to take also the course *Optimization 2*, giving more examples of techniques to study applications.

Module 1 Complexité des algorithmes

Module 2 Recherche opérationnelle

COMPLEXITÉ DES ALGORITHMES

Aims : The course consists in making the students aware of the notion of efficiency of an algorithm (particularly the algorithmical complexity), and teaches them how to distinguish between an *easy* and a *hard* problem in order to define the appropriate methods to solve them.

Content :
Turing machines. Efficiency of an algorithm, input encoding, size of an input, complexity analysis. Polynomial, pseudo-polynomial and non polynomial algorithmes. NP, Co-NP, NP-Hardness, NP-Completeness. Space complexity. Complexity and encoding.

RECHERCHE OPÉRATIONNELLE

Aims : Detail and extend the most useful techniques of operations research and apply some of them.

Content :
Linear programming, Integer linear and non linear programming, Lagrangian duality, Model combinatorial (linear and nonlinear) optimization problems encountered in multiple fields (telecommunications, transportation, sustainable development).

[PRRU35] PROGRAMMATION RAISONNÉE 1 (5 ECTS)

UE resp : BUREL Guillaume

Prerequisite (in french) :
Logique, programmation

Parcours : Génie logiciel (GL)

Effectif : 40

Aims :
Formal methods are more and more used in industry to raise the trustfulness in software correctness. This is in particular the case of critical application, but also to lessen production costs : indeed, less time and ressources will be allocated a posteriori to correct errors. This option presents several techniques that are used to verify computer systems, together with the foundation on which these techniques rely. It deals with being able to formally specify the behaviour of a program (programming language semantic), and being able to prove that this program verify some mathematical properties (mechanized formal proof) using deductive methods.

Module 1 Preuve formelle mécanisée

Module 2 Sémantique des langages de programmation

PREUVE FORMELLE MÉCANISÉE

Aims : Logic complements and initiation to proof techniques

Content :

- Logic reminders, propositional logic, predicate logic;
- classical vs. intuitionistic logic;
- λ-calculus (pure, simply typed, introduction to dependent types), Curry Howard isomorphism;
- Introduction to the proof assistant Coq;
- Automated deduction;
- Trial of SAT and SMT solvers.

SÉMANTIQUE DES LANGAGES DE PROGRAMMATION

Aims : To be able to specify the semantic of a small programming language, formalization of the semantic of the main constructs of imperative and functional languages.

Content :

Abstract syntax. The different families of semantics:

- Denotational semantic, big-step and small-step operational semantics of an imperative language;
- Call-by-value and call-by-name operational semantics of a functional language;
- Operational semantics of an object-oriented language;
- Implementation of interpreters in OCaml;
- Specification of a semantic in the framework K.

[PRRD35] PROGRAMMATION RAISONNÉE 2 (5 ECTS)

UE resp : DUBOIS Catherine

Prerequisite (in french) :
Logique, programmation.

Il est recommandé de suivre PROG1 au semester S5 auparavant, ainsi que LSF-VVL au semestre S3.

Parcours : Génie logiciel (GL)

Aims :
The course deals with the application of formal methods to verify the correct operation of software. Here, we are interested in static techniques, i.e. showing the correctness of the system or detecting errors even before execution. The simplest example is the use of typing, where certain erroneous behaviour is forbidden at compile time because it cannot be typed. Static analysis by abstract interpretation makes it possible to extend this approach to compute more precise properties than simple typing, for example the non-dereferencing of null pointers or the respect of the bounds of an array. A project will be the occasion to study scientific articles related to the static verification of software, and will be the subject of a bibliographical synthesis and a realization related to the studied articles.

Module 1 Analyse statique de programmes

Module 2 Projet

ANALYSE STATIQUE DE PROGRAMMES

Aims : Introduction to the main techniques for discovering errors in programs in a static way, more precisely by abstract interpretation.

Content :
- Non-standard semantics

- Abstract interpretation: notion of fixed points, lattice of values or properties, Galois correspondence

- Proof of correctness of an analysis with respect to a semantic

- Use of FramaC to perform a value analysis on a C program

PROJET

Aims : According to the chosensubject:

- Deepening of certain techniques,
- Discovery of new techniques,
- Opening up to leading applications,
- Use of Frama-C plugins, development of a new analysis, etc.

Content :

Bibliographic study and implementation.

This module cannot be made up in the second session.

[PYDS35] PYTHON FOR DATA SCIENCE (5 ECTS)

UE resp : KOUAMO Olaf

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM),Organisation des Entreprises (OE)

[SECD35] SÉCURITÉ AVANCÉE 2 (5 ECTS)

UE resp : MONTIBUS Ayfer-marie

Prerequisite (in french) :
Sécurité des systèmes d'information

Parcours : Génie logiciel (GL)

Effectif : 30

Aims :
The modules follows the SEC1 module, and focuses on the industrial cybersecurity (architecture, technologies, state of the art), the SOC and SIEM technologies (especially in the industriel environment), and how to bring cybersecurity in the industrial field (from risk analysis to implementation).

[SIGI35] SIMULATION ET GESTION DES INCERTITUDES (5 ECTS)

UE resp : DOSSANTOS-UZARRALDE Pierre-jacques

Prerequisite (in french) :

Programmation en C et/ou Python et/ou R dans un environnement UNIX/Linux

Algébre linéaire - Probabilités - Statistiques*

UE bienvenues : [IPS] Introduction à la Programmation Scientifique

[PSA] Programmation Scientifique Avancée

Parcours : Calcul Intensif et Données Massives (CIDM)

Effectif : 30

Aims :

Scientific computing through high performance computing (HPC) has become an essential tool for scientific, technological and industrial research. A discipline with not always well-defined contours, it brings together a set of mathematical and computer fields allowing the digital simulation of phenomena in physics, chemistry, biology, and applied sciences in general.

Its corollary, numerical simulation, provides an effective tool for predicting, understanding, optimizing, and even controlling the behavior of physical systems in the engineering sciences. The numerical simulation of complex multiphysical phenomena, respecting the scales in space and time, requires numerous calculations, which use and generate large volumes of data, on high-powered computers: this is high-performance computing. We associate a predictive role to numerical simulation applications. This raises the question of the gap between the application (observations) and the numerical simulation resulting from the modeling. Modeling and the resulting numerical simulation introduce sources of error

- Error on the model,

- Error on the inputs/outputs and/or natural variability of these inputs,

- Errors on the initial conditions,

- Error in the numerical approximation of the model.

Each source of error must be integrated into the prediction process.

Program of the EU

A- Parametric analysis: study of the model response on a more or less dense grid of the input parameters

a. Uncertainties: models, input data, parameters, numerical errors

b. Sampling techniques - Monte Carlo - LHS

c. ANOVA - sensitivity study - Kriging

d. Chaos polynomials - Meta model,

B- Verification and Validation

a. Bayesian approach - MCMC methods

b. Model calibration and validation

C- Design of experiments: selection of the best set of parameters on which the model will be computed to maximize the information on the relationship between the inputs and the outputs in order to build an approximation (less expensive in computation time): the response surfaces

D- Precise and efficient intensive calculation

a. Verification and increase of the numerical accuracy of a calculation code

b. Verification and optimization of statistical self-learning methods

[SYIR35] SYSTÈMES INTERAGISSANT EN RÉSEAUX (5 ECTS)

UE resp : SIMATIC Michel

Prerequisite (in french) : None

Parcours : Interactions Numériques (IN)

Effectif : 32

Module 1 Réseaux et Cloud

Module 2 Objets Communicants

RÉSEAUX ET CLOUD

OBJETS COMMUNICANTS

[TCEF35] TRONC COMMUN 2 (2 ECTS)

UE resp : AVRIL Nathalie

Prerequisite (in french) : None

Parcours : Génie logiciel (GL),Mathématiques appliquées (MA),Organisation des Entreprises (OE)

[TCJE35] TRONC COMMUN 1 (2 ECTS)

UE resp : ABDELLAOUI Mohamed

Prerequisite (in french) : None

Module 1 Serious Game

Module 2 Droit et cybersécurité

SERIOUS GAME

DROIT ET CYBERSÉCURITÉ

[VICC35] VIRTUALISATION ET CLOUD COMPUTING (5 ECTS)

UE resp : DIAKHATE François

Prerequisite (in french) : None

Parcours : Calcul Intensif et Données Massives (CIDM)

SEMESTER 6

Contents

[BLOC36] BLOCKCHAIN (4 ECTS)

UE resp : DUMBRAVA Stefania

Prerequisite (in french) :
Bonnes compétences en programmation Java.

Aims :
The pedagogical objective is acquiring basic knowledge concerning the technical principles behind distributed databases and the Blockchain technology, as well as its use in the creation of crypto-currencies and of "smart contracts". The unit serves as an introduction to the main blockchain development tools. The projects will consist of designing an application or a blockchain protocol, implementing it in Solidity or in Max, and presenting the final product.

Module 1 Blockchains classiques

Module 2 Blockchains de nouvelle génération

BLOCKCHAINS CLASSIQUES

Aims : Introduction to classical blockchains.

Content :
The unit will give a presentation of the following topics: introduction to Bitcoin (the structure of transactions, cryptographic primitives, the protocol), the basis of the Ethereum technology (le virtual machine and the execution of smart contracts), introduction to Smart Contract programming in Solidity and practical handling of a blockchain ("lightning channels" and "atomic swaps").

BLOCKCHAINS DE NOUVELLE GÉNÉRATION

Aims : Introduction to new generation blockchains.

Content :
The unit will give a presentation of the following topics: the basis of distributed systems (system models, communication primitives, the CAP theorem, consensus), Proof of Work blockchains and BFT consensus, multi-agent simulation for blockchain development, programming with the Max multi-agent simulator.

[MOOC36] MOOC6 (2 ECTS)

UE resp : LIM Thomas

Prerequisite (in french) : None

Aims :

The aim is that the students learn to learn by themselves with Massive Online Open Courses. For that the student chooses a technical subject related to ENSIIE and develop that with a MOOC.

[RDEV36] PROJET RECHERCHE ET DÉVELOPPEMENT (4 ECTS)

UE resp : MOUGEOT Mathilde

Prerequisite (in french) :
Les UE MERR23 ou MALE23 sont un plus.

Effectif : 15

Aims :
Initiation of research and development work to meet an industrial need.

Implementation of a proof of concept.

INDEX