Computer Science and Applied Mathematics
Department
Third year Semesters 9 and 10

2016-2017

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1 Schema
Semester 9

Informations Systems

Distributed systems and computing

Safety Critical System Development

Computer vision and image synthesis

Advanced Middleware and Networks

Multimedia Data Access

Cyber Physical System Development

English, lectures and work experience 2A

Semester 10

Long Project

Internship

Numerical Method for Scientific Computing

Atmosphere Modeling

Stochastic Forecasting and Bayesian Analysis
2 Semester 9

2.1 Teaching unit Informations systems

Code : NEI-sisi

ECTS credits : 5

Contact Y. Ait-Ameur yamine@enseeiht.fr

Instructor N. Aussenat Gilles, P-Y. Bonnetain, M. Boughanem, S. Mouysset

Prerequisites Basic notions of database systems, first order logic, probabilities and statistics.

Keywords Security, risk analysis, information retrieval, classification, data mining, similarity measures, association rules, ontologies, knowledge based reasoning

Objectives, acquired skills This class aims at introducing advanced concepts and techniques related to the management of information systems.

Content This class is divided in four main parts. The first part is related to security of information systems. It addresses the basic notions of security and risk analysis and the deployment of security policies in information system. The second part is devoted to the different techniques used in information retrieval and the different set up search algorithms. It studies the design of information search engines. The third part deals with the semantic web and knowledge based reasoning using ontologies and description logics. Finally, the fourth part is devoted to data mining through exploratory methods (similarity measures, association rules, ACP) and supervised or unsupervised classification methods (SVM, kmeans, graph cuts).

Hours (units of 1h45)

- security of information systems : 9 lectures
- data mining : 9 lectures
- web semantic : 5 lectures
- information retrieval : 5 lectures
Assessment

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Session 2

Idem session 1.
2.2 Teaching unit Distributed systems and computing

Code : NEI-scr
ECTS credits : 5

Contact P. Amestoy amestoy@enseeiht.fr

Overview Principles and concepts of distributed computing and examples of applications through distributed services are described in the first course. Programming issues for high performance computing, execution modelling of parallel programs, and API for large scale distributed memory computers (Message Passing Interface MPI) are described in the second course. Cloud computing both from a technical side and from juridic, marketing and commercial sides is then introduced in the last course.

Course Distributed computing

Instructor Philippe Queinnec

Prerequisites A practical programming experience and fundamental knowledge about operating systems, parallel computing, middlewares and networks are required. Basic knowledge of formal methods such (temporal) logic and transitions systems are also worthwhile.

Keywords Distributed algorithms, causality, consensus, replication

Objectives, acquired skills This class aims at providing a state of the art about principles of distributed computing and some examples of their application through distributed services: distributed file systems, dependable systems, distributed replicated memories, distributed transactional systems, etc

Content Principles and concepts of distributed computing are described and their use in distributed systems. After a short introduction, the standard model of distributed computing based upon the causality relation is pointed out. Then, a survey of generic distributed algorithms is performed: datation, causally ordered and atomic protocols, mutual exclusion, consensus, termination, global snapshots and checkpointing, memory consistency, etc
Some distributed system examples are especially emphasized: distributed file systems (NFS, AFS), atomic multicast protocols (Ensemble, Java Groups, etc), distributed memories and their various consistency semantics, distributed simulation (HLA standard), etc.

Current trends and/or more specific applications close this survey of distributed computing foundations: peer-to-peer computing, sensor networks, mobility, ambient systems, etc.

A set of specific examples are studied as short supervised lab sessions along the classes.

Hours (units of 1h45) 9 lectures

Assessment

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Session 2

Idem session 1.

Bibliography


Course High performance shared and distributed memory computing

Instructor Patrick Amestoy\footnote{http://amestoy.perso.enseeiht.fr/} and Alfredo Buttari\footnote{http://buttari.perso.enseeiht.fr/index.html}
Prerequisites Computer architecture, operating system and synchronisation mechanisms, programming

Keywords High performance computing, distributed and shared memory programming, parallel algorithms

Objectives, acquired skills Programming and algorithmic issues for large scale parallel computers (hundreds to hundred thousands of core) are addressed in this lecture

Content This module begins with a general introduction to high performance computing and programming where the general concepts used in the design of high performance computers (from multicore cache based memory computers to large clusters of nodes) are described along with the main issues related to efficient high performance programming (from sequential code optimization techniques up to shared memory parallel programming and distributed computing). Afterward, notions on architecture and execution modeling of a parallel program are provided aiming at accurate performance prediction. The notions of speed-up, iso-efficiency, scalability are also introduced at this moment. The module is concluded with some brief concepts of Grid computing and the related issues.

The module consists of nine lectures of two hours each organized as follows:

- Lecture 1. Introduction to high performance computing and programming
- Lectures 7-8. Algorithmic issues in the design of parallel programs: data partitioning, task mapping and dynamic scheduling.

The module also includes 2 to 4 hours of supervised lab during which students experience distributed memory computing in a message passing environment. PVM ("Parallel Virtual Machine") and XPVM (interactive trace analysis) are used to develop and
validate a relatively simple application such as the iterative block Jacobi method for the solution of banded linear systems of equations. At the end of the lab sessions the students are asked to design and develop a distributed memory dynamic scheduler to automatically adapt the distribution of the parallel tasks of this application to the load of the nodes of the target computer.

**Hours** (units of 1h45) 10 lectures

**Assessment**

*Session 1*

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*Session 2*

Idem session 1.

**Bibliography**

- Barbara Chapman, Gabriele Jost, Ruud van der Pas “Using OpenMP: Portable Shared Memory Parallel Programming (Scientific and Engineering Computation)”
- Peter Pacheco “Parallel Programming with MPI”

**Course** Cloud computing

**Instructor** Daniel Hagimont and Laurent Broto

**Prerequisites** A general background in operating systems and networks is required.

**Keywords** Virtualization, SAAS, PAAS, IAAS, Cloud

**Objectives, acquired skills** This class aims at providing an overview of concepts which characterize cloud computing. These concepts are covered following two dimensions:

- a technical dimension which presents the different types of clouds and the involved technologies,
• a transverse dimension which covers organizational, legal and financial aspects.

This overview will possibly be completed with illustrative case studies from industrial projects.

Content
This class is divided into two parts:

• Technological point of view of the Cloud
  – Motivation for cloud computing
  – Virtualization techniques (full virtualization, para-virtualization) and contribution to the Cloud
  – Types of Clouds (IaaS, PaaS, SaaS)
  – Scalability, reliability and security issues

• Transverse point of view of the Cloud
  – Organizational aspects (e.g. impact of on demand resource allocation on organizations)
  – Legal aspects of the Cloud (e.g. impact of the location/nationality of hosting centers)
  – Financial aspects of the Cloud (e.g. impact on business models)

Hours (units of 1h45) 8 lectures

Assessment

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Session 2
Idem session 1.

Bibliography

2.3 Teaching unit English, lectures and work experience 2A

Code: NEI-elwe
ECTS credits: 5
Contact: anne.brittain@enseeiht.fr

Overview

Course: English

Instructor: Anne Brittain

Prerequisites

Keywords

Objectives, acquired skills

Content

Hours (units of 1h45)

Assessment

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Session 2
Idem session 1.

Bibliography
2.4 Teaching unit Safety Critical System development (Certification)

Code: NEI-cl

ECTS credits: 5

Keywords
Static analysis, Deductive verification, Model checking, Satisfiability, Abstract interpretation, Safety, RAMS, MBSA, Stochastic testing, Test generation, Certification, Qualification

Contact Marc Pantel Marc.Pantel@enseeiht.fr

Instructor
Marc Pantel, Xavier Thirion, Pierre-Loïc Garoche, Pierre Roux, Jean-Paul Blancard, Christelle Seguin, Pierre Bieber, Jonathan Spraul, Hélène Waeselink

Objectives, acquired skills
Study of the main constraints and technologies for the development of safety critical systems. Understand and implement static and dynamic analysis technologies: deductive verification, model checking, abstract interpretation, test generation, safety analysis. Understand certification and qualification purposes and applications.

Prerequisites
- Functional Programming
- Modular Imperative Programming
- Object and Event Driven Programming
- Mathematical tools for computer science
- Centralized systems
- System and Software Engineering
- Concurrent systems
- Formal specification

Content
- Static Analysis (9 C + 3 TP + 2 BE)
  - Deductive verification: Hoare logic, Weakest precondition calculus
  - Model checking: BDD, SMT
  - Abstract interpretation
- Safety and tests (12 C + 2 TP)
- RAMS
- Stochastic approach (MTBF, ...)
- Model based approach safety
- Stochastic test
- Test generation
  - Certification and Qualification (1 C)
    - Safety critical systems
    - Certification principles and standards
    - Qualification principles and standards

**Hours** (1h45 slots) 22 C, 5 TP, 2 BE, 1 Exam

**Assessment** Written exam and Practical session

**ECTS credits** : 5

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**Session 3**

Idem session 2.

**Bibliography**

-
2.5 Teaching unit Advanced Systems and Networks

Code: NEI-ira

ECTS credits: 5

Keywords
Cloud, Big Data, advanced networks

Contact Alain Tchana Alain.Tchana@enseeiht.fr

Instructor
Alain Tchana, Daniel Hagimont, Emmanuel Chaput

Objectives, acquired skills
Study advanced system services, especially those related to emerging fields that are Cloud Computing and Big Data. Study advanced network services.

Prerequisites
- Operating systems
- Concurrent programming
- Database systems
- Object-oriented programming
- Basic middleware (client-server, messages)
- Basic networks

Content
- Advanced systems
  This first part of the teaching unit presents advanced system services in the field of Cloud Computing and Big Data. This domain is characterized by the need for elastic applications (covered in the autonomic systems part), and a need for optimal resource management (for Cloud and Big Data environments).
    - Autonomic systems
      * Software components (Fractal)
      * Autonomic systems (Tune, RoboConf)
    - Cloud computing
      * Cloud Platforms (OpenNebula, OpenStack, Eucalyptus)
      * Virtualization (Xen, KVM, Docker)
    - Big Data
      * MapReduce (Hadoop)
      * filtering chains (TwitterStorm)
• Advanced networks
This part of the teaching unit complements second year lectures related to networking. The objective is to provide a broad overview of major evolutions in data networks. The various aspects of these evolutions are presented.

– Technological evolutions related to wireless communications
– Applicative evolutions related to voice over IP
– Required architecture evolutions, in terms of mobility, multipoint and quality of service

Hours (unit of 1h45) 17 lectures, 1 tutorials, 10 practical works, 2 exam

Assessment

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Session 2
same as session1.

Session 3
same as session1.
2.6 Teaching unit Cyber Physical System Development

Code: NEI-sce

ECTS credits: 5

Keywords
Cyber Physical System, Control and Command, System engineering, Requirement engineering, Software architecture, Embedded systems, Real time operating systems and networks

Contact Marc Pantel Marc.Pantel@enseeiht.fr

Instructor
Marc Pantel, Yamine Aït Ameur, Raphaël Faudou, Arnaud Dieumegard, Jean-Luc Sharbarg, Maurice Fadel, Eric Tournier, Léopold Sépulchre, Victor Gibert

Objectives, acquired skills
Study of the main constraints and technologies for the development of cyber physical systems: i.e. systems that interacts with their environment using sensors and actuators, and especially safety critical real-time embedded systems

Prerequisites
• Functional Programming
• Modular Imperative Programming
• Object and Event Driven Programming
• Mathematical tools for computer science
• Centralized systems
• Concurrent systems
• System and Software Engineering
• Real time systems

Content
• System Engineering (6C, 2TP)
  – System level
  – Operational, Functional, Logical, Physical Architecture
  – MBSE (Model Based Software Engineering)
  – SysML language
  – Requirement engineering, Separation of Concerns
• Embedded systems (7C)
– Avionics architecture, A320 Fly by wire use case, Integrated Modular Avionics
– Real Time Operating Systems: ARINC 653, OSEK use cases
– Real Time Networks: AFDX, CAN use cases

• Control & Command (5C + 9TP)
  – Hybrid continuous/discrete systems
  – State feedback control
  – Robustness, Correctness
  – Model Based Development: Modeling, Simulation, Code generation, Integration
  – Simulink, PSim

**Hours** (1h45 slots) 18 C and 11 TP, 1 Exam

**Assessment** Written exam and Practical session

**Session 1**

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**Session 3**
Like session 2.

**Bibliography**

• ...
2.7 Teaching unit Computer vision and image synthesis

Code : NEI-vsi

ECTS credits : 5

Contact schambon@enseeiht.fr

Overview This lecture introduces image processing tools, like image restoration, edge detectors, segmentation, and, computer vision tasks, like stereo-photometry, stereoscopy. Analysis process and image synthesis are also described with volume surface model, discrete surface models, parametric models. Moreover, some transversal notions are detailed: multi-resolution, space partition. Finally, this lecture will be illustrated with some applications in augmented reality, in 2D and 3D, like, for example, medical image processing.

Course Computer vision

Instructor Sylvie Chambon, Vincent Charvillat, Jean-Denis Durou, Philippe Marthon.

Prerequisites Teaching unit of the second year (Image, Modelling and Rendering)

Keywords Stereophotometry, Segmentation, Image processing.

Objectives, acquired skills There are two objectives : (1) to consolidate the knowledge of the second year in image processing and computer vision and (2) to acquire new competences about the 3D reconstruction (stereo-photometry).

Content
L1-2 : Image formation: geometric and photometric approaches
L3-4 : 3D Reconstruction with stereo-photometry
PW1-2 : Stereo-photometry
L5-7 : Image processing and segmentation
PW3-4 : Image mosaicing
L8-9 : Geometric characteristics and structure extraction
PW5-6 : Calibration
L10-11 : Medical imaging
PW7 : Medical application
EXAM : Computer vision

**Hours** 11 lectures, 7 practical works
**Assessment** 1 exam

**Session 1**

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**Session 2**

Idem session 1.

**Bibliography**


**Course** 3D Modeling and Visualization

**Instructor** Géraldine Morin, Simone Gasparini

**Prerequisites** Teaching unit of the second year (Image, Modelling and Rendering)

**Keywords** Geometric models, surface mesh, OpenGL, OpenMesh.

**Objectives, acquired skills** The main objective is to generalize the knowledge of the second year about curve models to 3D models.

**Content**

- L1 : Object modelling with discrete surface models
- L2-3 : Parametric models for CAD: B-splines, NURBS
- L4 : Subdivision surface
- L5 : Other representation models: implicit, fractal
- PW1-2 : OpenGL, OpenMesh:
- PW3-5 : Subdivision algorithm, particle system, fractal surface/volume
- EXAM : Analysis process and image synthesis

**Hours** 5 lectures, 5 practical works
**Assessment** 1 exam
Session 1

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Session 2

Idem session 1.

Bibliography

2.8 Teaching unit Multimedia Data Access

Code: NEI-adm

ECTS credits: 5

Contact charvillat@enseeiht.fr, simone.gasparini@enseeiht.fr

Overview The goal of this teaching unit is to present the latest approaches for accessing multimedia data in an efficient and smart way. It is the natural extension of the teaching units of the second year and it is complementary to the course “Image Synthesis and Vision” of the third year. In this unit the focus will be on the visual interactions, both 2D and 3D, in particular on the design of interactive, multi-modal interfaces and their underlying technological requirements. The topics concerning visual data will be completed with the analysis, the indexing and the compression of video streams. Finally, the unit also covers audio data, which is not fully treated in the other units of the multimedia track, with a particular attention to speech recognition and the analysis of musical signals.

Course Design and technologies for multimedia interfaces

Instructor Sylvie Chambon, Simone Gasparini, Axel Carlier.

Prerequisites UE 1A (Technologie objet (Code IMA-1A-TOB)), UE 2A (Intergiciels (Code IMA-2A-INT), Image, modélisation et rendu (Code IMA-2A-IM-IMG)).

Keywords Interfaces, HTML5 multimedia extensions, Javascript multimedia API.

Objectives, acquired skills Three main objectives: characterization of the main features of multi-modal interfaces (time constraints, synchronization), incremental and participative design of multi-modal interfaces, examples of multimedia web services (video captioning, multimedia presentations using the SMIL language)

Content
C1: Design and technologies for multimedia interfaces
C2-C3: Introduction to the multimedia extensions of HTML5/Javascript
TP1-4 : Designing new video interactions in HTML5

**Hours**  3 lectures, 4 TPs

**Assessment**  1 exam

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**Session 1**

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**Session 2**

Idem session 1.

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**Bibliography**


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**Course** Augmented and Mixed Interfaces

**Instructor** Simone Gasparini, Sylvie Chambon.

**Prerequisites** UE 1A (Technologie objet (Code IMA-1A-TOB))), UE 2A (Génie logiciel (Code IMA-2A-GLS ), Image, modélisation et rendu (Code IMA-2A-IM-IMG)).

**Keywords** 2D/3D Interaction, visual tracking, mixed reality systems.

**Objectives, acquired skills**  Two main objectives: designing interactive interfaces mixing 3D models and natural/synthetic images for a wide range of applications (visual special effects, simulation, industrial maintenance...), implementation of interactive interfaces using popular open-source frameworks (OpenCV, OpenGL) and optimization of their performances (GPU, multi-threading).

**Content**

C1 :  Augmented and Mixed Interfaces
C2-C3 :  Camera tracking for augmented reality applications
TP1-4 :  Implementation of an augmented reality application using OpenCV and OpenGL

**Hours**  3 lectures, 4 TPs
Assessment  1 exam

Session 1
Exam in common with the first course.

Session 2
Idem session 1.

Bibliography


Course  Digital audio: speech and music

Instructor  Jérôme Farinas.

Prerequisites  UE 2A (traitement et analyse des données audiovisuelles), UE 1A (Probabilités et statistiques).

Keywords  Speech recognition, Automatic transcription systems, Musical analysis.

Objectives, acquired skills  This part of the course completes and extends the basic topics on audio processing introduced during the course of the second year “Traitement des données audiovisuelles”. The course will mainly focus on the state-of-the-art techniques for speech recognition and transcription.

Content
C1 : Digital audio: speech and music and relevant interfaces
C2 : Speech description and parametrization
C3 : Speech modeling using dynamic programming and hidden Markov models
C4 : Transcription systems
TP1-3 : Some examples of speech transcription systems
    + supplementary session on Thursday afternoon for M2R validation

Hours  4 lectures, 3TPs

Assessment  1 exam
Session 1

Exam in common with the forth course

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Session 2

Idem session 1.

Bibliography

- C. Road, L’audionumérique, musique et informatique, Dunod 2007.

Course  Analysis, coding and indexing of videos

Instructor  Vincent Charvillat, Philippe Joly.

Prerequisites  UE 2A (Traitement et analyse des données audiovisuelles, Image, modélisation et rendu (Code IMA-2A-IM-IMG )), UE 1A (Probabilités et statistiques).

Keywords  Compression, indexing, information theory, MPEG standards.

Objectives, acquired skills  Starting from the information theory, the course introduces the theoretical aspects of video compression that allow to present the latest, state-of-the-art compression standards. Similarly, the basic concepts for video indexing are introduced (shape, color, texture and motion indexing) and explained in the context of the current standards and of the current research trends in multimedia information retrieval.

Content

C1 : Compression: source model, entropy of order 0, 1, k
C2 : Transform compression and motion compensation, trade-off throughput/quality
C3 : Compression standards and compression-indexing relationship
C4-5 : Video indexing
TP1-2 : Parametrization of a codec and content search
+ supplementary session on Thursday afternoon for M2R validation.

**Hours**  5 lectures, 2TPs  
**Assessment**  1 exam

**Session 1**

Exam in common with the third course.  
+ 1 Exam (extended by 1h for M2R).

**Session 2**  
Idem session 1.

**Bibliography**

2.9 Teaching unit Numerical Method for Scientific Computing

Code: NEI-sc

ECTS credits: 5

Contact Serge Gratton gratton@enseeiht.fr

Overview
Forecasting the behavior of a complex dynamical system using (physical) observations relies on the solution of an inverse problem. Solution techniques to solve this problem are often called data assimilation techniques. The purpose of this module is to present the algorithms that are used to solve real-life problems described in the so-called variational approach, in the case where they involve a large number of degrees of freedom. These algorithms are at the intersection between optimization, inverse problems, and optimization theory.

Since many problems in scientific computing involve the solution of very large systems of linear equations, a purpose of the module is also to describe the mathematical techniques that can be used to tackle the problems on front-end parallel architectures.

Course Algorithms for sparse matrices

Instructor Alfredo Buttari, Serge Gratton and Joseph Gergaud

Prerequisites
Use of finite differences and finite elements for solving PDEs. Use of the LU factorization for solving linear systems of equations. Unconstrained and KKT conditions for optimization problems.

Keywords
Parallel computing, sparse direct solver, sparse iterative solver, duality theory

Objectives, acquired skills
The aim of this course is to describe up-to-date techniques for the solution of large linear systems on parallel computers. It also introduce duality theory that is a key ingredient in many linear programming solution methods.

Content
This sub-module begins with four lectures that present parallel algorithms to solve linear systems arising from partial differential equations on parallel computers. The solution methods depend on the discretization technique that is used: the finite difference and finite element approaches are considered. A special emphasis will be put on the solution of time dependent problems by implicit technique, where scalability for massively parallel computations is reached using suitable mesh partitioning techniques.

The sub-module continues with three lectures of direct solution methods for sparse linear systems. The objective of these lectures is to provide students with the basic theory behind the factorization of sparse matrices as well as the issues related to the implementation of a sparse, direct solver on modern, parallel computing architectures. Specifically the lectures will focus on the cost and efficiency of the involved basic linear algebra operations, the issues related to memory consumption, the exploitation of parallelism and concurrency as well as some aspects of numerical stability.


The sub-module is concluded with three lectures on duality in optimization and on automatic differentiation.

Hours (units of 1h45) 10 lectures

Assessment

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Session 2
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Bibliography

- Authors, Title, Publisher, edition, year

Course Data assimilation

Instructor Serge Gratton
Prerequisites


Keywords

Inverse problems, well-posedness, 4D-Var, Kalman filters, inexact and truncated iterative solvers for unconstrained optimization, maximum likelihood estimation.

Objectives, acquired skills

Provide theoretical background and algorithms for solving inverse problem. Explore techniques used for forecasting the state vector of an observed system that is modeled using stochastic differential equations.

Content

The sub-module begins with three introductory lectures describing the mathematical foundation of inverse problem theory and parameter estimation in the case where the model and observation errors are supposed to be Gaussian. In practice, the problem often takes the form of a differentiable optimization problem with constraints that are both nonconvex and nonlinear. Effective solution methods rely on globalized optimization schemes that will be presented in three lectures.

Having insisted on the importance of having access to the derivatives of the functions and constraints, we will present in one lecture a survey on techniques to differentiating functions. These techniques range from sophisticated finite differences approaches, using more or less compact schemes, to automatic differentiation techniques. However there are still situations where either the function to optimize is mathematically complex, or its solution involves a large software. In this case evaluating derivatives may be unaffordable in terms of computational cost or software development, and practitioners fall back on derivative free optimization algorithms that will be briefly outlined in one lecture.

Hours (units of 1h45) 9 lectures

Assessment

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Session 2

Written or oral exam
Bibliography

- G. Allaire “Analyse numérique et optimisation”, 2005
- M. Minoux ”Programmation mathématique”, 1983.

Course Discrete optimization and metaheuristics

Instructor Nicolas Durand, Sonia Cafieri

Prerequisites

Keywords

Meta-heuristics, Genetic Algorithms, Ant Colony Optimization, Simulated Annealing, Particle Swarm.

Objectives, acquired skills

Content

The first part of this submodule is concerned with optimization problems where part of the unknowns are integer variable, the others being real. In this case it is necessary to re-consider algorithms and criticality since the notion of derivative is not relevant for the optimization problem as far as the integer variables are concerned. The course starts with techniques for linear programming in the case where all unknowns are integer, and is concluded with algorithms for mixed, non linear programming. The particular case of linear programs with mixed variables will also be addressed. Some of the tools presented in this course are based on branch and bound technics that rely on interval arithmetics. In some optimization problems, variables are neither real, nor integer and or the optimization function is the result of a “black box” simulation. We present meta-heuristics such as Simulated Annealing, Genetic Algorithms, Ant Colony Optimization and other population based stochastic algorithms that are generally very effective to address these problems.

Hours (units of 1h45) 7 lectures + 1 practical works
Assessment

Session 1

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Session 2

Idem session 1.

Bibliography

- J. Dréo and A. Pétrowski and P. Siarry and E. Taillard “Métaheuristiques pour l’optimisation difficile”
2.10 Teaching unit  Atmosphere Modeling

Code :  NEI-msc  
ECTS credits :  5

Contact  Frédéric Ferry  frederic.ferry@meteo.fr

Instructor
Frederic Ferry, David Pollack, Rachel Honnert, Fabrice Voitus, Olivier Pannekoucke, Pascal Laveau, Marie-Pierre Traulle

Prerequisites
This course is intended for science students, with basic knowledge in physics (CPGE program)

Keywords

Objectives, acquired skills
After this course, the students will be able to :

- Describe the general circulation of the atmosphere.
- Understand the dynamical laws that govern the evolution of the atmosphere.
- Exhibit the large-scale equilibria of the atmosphere. Understand mid-latitudes dynamics in the quasi-geostrophic theoretical framework.
- Use an idealized quasi-geostrophic model of the atmosphere to simulate the evolution of mid-latitude disturbances and cyclogenesis.
- Understand the numerical methods that are used in Numerical Weather Prediction (NWP) models to solve the dynamical equations of the atmosphere.
- Apply and test the stability of these numerical methods in simplified frameworks.
- Understand how NWP models deal with physical processes through the use of physical parametrization.
• Understand the chaotic behavior of the atmospheric dynamics.
• Know how to manage risk management and make a decision in uncertain context.

Content

• Mid-latitudes dynamic meteorology.
• Introduction to Numerical Weather Prediction and physical parametrization.
• Atmospheric dynamics and unstable space.
• Introduction to statistic software R.
• Risk Management (courses and conferences).

Hours 21 lectures, 9 practicle works

Assessment Session 1

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Session 2

Idem session 1.

Bibliography

• Malardel S., Fondamentaux de météorologie, éditions Cépaduès, 2005
• Jean Coiffier, Les Bases de la prévision numérique du temps, Météo-France Collection ” Cours et Manuels ” n° 18, 258 p., 2009
• Joly, A., Les tempêtes, les dépressions. Cours et manuels n°7. Météo-France, 1992
• The R Project for statistical computing: http://www.r-project.org/
2.11 Teaching unit Stochastic Forecasting and Bayesian Analysis

Code: NEI-ps

Keywords
stochastic calculus, modelling, nonlinear filtering, data assimilation
risk, Bayesian theory, decision

Contact Olivier Pannekoucke olivier.pannekoucke@meteo.fr

Instructor
Olivier Pannekoucke, Pascal Laveau

Objectives, acquired skills
This course aims at developing competences in optimized risk managing and uncertainty by mastering the modeling tools (stochastic forecasting) and statistics (Bayesian analysis and decision theory).

Prerequisites
Elementary knowledge in statistics is necessary, as well as basic knowledge in simulation model operating, particularly data assimilation.

Content

1. Stochastic forecasting
   - Fokker-Planck equation. Solution to the stochastic-dynamic problem with Monte-Carlo method.
   - Random numbers
   - Ensemble assimilation: ensemble Kalman filters, particle methods,
   - Optimality diagnostics in data assimilation
   - Probabilistic forecasting: perturbation method (stochastic noise, singular vectors, breeding), calibration, validation, basic knowledge in economic value

2. Bayesian analysis and decision theory
   - Decision considering information
   - Modeling of a priori knowledge
   - Risk and decision in uncertain future
   - A posteriori computation
   - Risk and decision
• Application
  – Conference on examples of applications (forest fires ...)
  – Optimized risk managing

**Hours** (unit of 1h45) 21 lectures, 9 practical works

**Assessment**

**ECTS credits**: 6

**Session 1**

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**Session 2**

Idem session 1.

**Bibliography**

• Christian Robert, Le choix Bayésien, principes et pratique, Springer

• James O. Berger, Statistical Decision Theory and Bayesian Analysis, Springer

• stochastic calculus, modelling, nonlinear filtering, data assimilation.
  – Manneville P., Instabilité, chaos et turbulence, Ellipses.
  – Bergé P., Pomeau Y. and Vidal C., L’ordre dans le chaos, Hermann.
  – Kalnay E., Atmospheric modeling, data assimilation and predictability, Cambridge.
3 semester 10

3.1 Industrial Approach for Software Development and Long Project

Industrial Approach for Software Development

Contact  Christophe Pinaud (EADS-Astrium) christophe.pinaud@astrium.eads.net
Instructor  Alain Bret (Capjaya), Christophe Pinaud, Béatrice Leger (EADS-Astrium)

Objectives, acquired skills
Understand the need and practices for a software development industrial approach; implemented through the long project. At the end of this course, students will be in a position to:

• Explain the usefulness of organizing and anticipating software development.
• Understand and explain the life cycle development of a software project. Identify its advantages, disadvantages and risks.
• Understand the usefulness of each phase of a project, in order to deliver a product that satisfies the customer, on time, on cost and on schedule:
  – Set up the project (tasks definitions, project organisation, software quality objectives),
  – Capture and define the needs,
  – Translate the needs into the specification,
  – Develop a product that meets the needs,
  – Define a validation strategy,
  – Deliver the product.
• Knowledge of processes:
  – To be an actor in the process definition,
  – To understand a processes mapping,
  – To explain the organisations maturity principles,
  – To breifly describe a maturity model (CMMI).

Content
The training consists of four modules:
• One module dedicated to the development process and maturity of the organization
Three modules dedicated to the "industrial SW development approach" connected to the long project which extends over a period of six weeks.

- Introduction and general overview (before starting long project)
- Software Development Life Cycles. Setting up a project. Requirements engineering to capture and define the needs (at long project kick off). Software quality.
- Software validation and Software configuration strategy and principles (during long project, 3rd week)
- Product Delivery Product (during long project, 5th week)

**Long Project** A five-week project where students work in groups of five.

ECTS credits : 8

**Hours** (unit of 1h45) 8 lectures

### 3.2 Internship

A major six-month internship after completing the course work.
ECTS credits : 22