APPLIED MATHEMATICS FIELD_12 ECTS

Introducing

Description

Évaluation

L'évaluation des acquis d'apprentissage est réalisée en continu tout le long du semestre. En fonction des enseignements, elle peut prendre différentes formes : examen écrit, oral, compte-rendu, rapport écrit, évaluation par les pairs...

Practical info

Location(s)

Toulouse

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Partial Derivative Equations 1

Introducing

Description

Modeling with PDE (linear PDEs in one dimension space)
1. Transport and wave equation
2. Heat equation
3. Schrödinger¿s equation,¿

Exact resolution of PDE in one dimension space
1. Characteristic method (transport, wave)
2. Variable separation (heat, wave, Schrödinger,¿), use of the linearity (superposition principle) and link with Fourier series
3. Fourier transform
4. Dissipative and dispersive phenomenon

Finie Difference Method in one dimension space
3. Consistancy, order, stability, scheme convergence
4. Courant-Friedrichs-Levy condition (CFL)

Objectives

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

• Classical linear one dimensional PDE (heat, transport, wave...), their exact resolution and the qualitative behavior of their solutions
• The Finite Difference method in one dimension space to solve PDE

The student will be able to:
• Solve linear PDE in one dimension space (characteristic method, variable splitting, superposition principle, Fourier transform)
• Implement Finite Difference method in one dimension space, coupled with numerical solving method for ODE in order to solve PDE.

Necessary prerequisites

Linear Algebra: matrix manipulation, eigenvalues and eigenelements, solving of linear differential equations.

Ordinary differential equations: modeling, existence of solutions, qualitative study, numerical simulation (convergence, stability, order)

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Inferential statistics

Introducing

Description

Syllabus (detailed contents):

• Review of the definitions and properties of the usual distributions (normal, Chi-square, Student's, Fisher's, Gaussian vectors, etc.) and probabilistic tools (law of large numbers, central limit theorem, Slutsky's lemma)
• Estimation in a parametric model: method of moments, maximum likelihood
• Cramer-Rao bound, and efficiency of an estimator
• Confidence interval for the mean and the variance of a Gaussian or a non-Gaussian sample
• Parametric hypothesis testing: concept, tests on the mean and the variance of a Gaussian sample, tests on a proportion, p-value, test for comparing two independent Gaussian samples, Neyman-Pearson's lemma, maximum likelihood ratio tests

Objectives

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

• defining a parametric model using usual distributions, such as normal, exponential, Bernoulli, Poisson, etc
• parameter estimation in a parametric model
• confidence interval construction
• hypothesis testing

The student will be able to:
• Model a situation using usual probability distributions, and manipulate them
• Estimate parameters in a parametric model and study the properties of these estimators
• Construct a parametric confidence interval
• Construct a parametric hypothesis testing

Necessary prerequisites

Probability and Statistics (2MIC)

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Project

Introducing

Description

Program (detailed contents):

Elements of Scientific Communication:
1. Introduction to Latex
2. Introduction to Beamer
3. Communication in applied mathematics: document structure (reports, slides), key points: modeling, analysis, simulation, tests

Mathematical modelling project : to be chosen in a list of possible projects.

Objectives

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

• Principles of mathematical modeling of an application problem in relation to another discipline or a particular industrial sector
• Self-evaluation of the results obtained in relation to the objectives.

The student will be able to:
• Interact with a specialist or engineer from another discipline
• Organize collaborative work in small groups
• Define the framework and specifications of an original mathematical modeling problem
• Conduct the necessary bibliographic research to solve the problem
• Develop the deterministic and/or stochastic model adapted to its resolution
• Implement its numerical resolution
• Report in writing and orally on the results obtained

Necessary prerequisites

Dynamical systems, advanced probabilities, data analysis.

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MCMC methods

Introducing

Description

Program (detailed contents):
- Simulation of random variables and vectors: pseudo-random numbers, simulation by the inversion method of the probability distribution function, by the acceptance-rejection method and by specific simulation methods.
-Classical Monte Carlo methods: implementation, variance reduction by different methods (control variate, importance sampling, antithetic variates method).
- Markov chain Monte Carlo methods: reminders on Markov chains, Markovian law of large numbers, Metropolis-Hastings algorithm.
- Application with the Python software

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):
- The fundamental principles of simulating random variables and vectors.
- The classical methods for variance reduction when approximating numerically integrals by means of the Monte Carlo method.
-The approximation of integrals by means of the Monte Carlo method using Markov chains.

The student will be able to:
- Generate a real random variable by the inversion method.
- Simulate a random vector by the acceptance-rejection method.
- Choose appropriate techniques for variance reduction (control variate, importance sampling, antithetic variates method).
- Use the Metropolis-Hastings algorithm generating a reversible ergodic Markov chain with prescribed stationary distribution.

Necessary prerequisites

Probability and Statistics (2MIC Semester 4).
Probability and Data Analysis (3MIC Semester 5).
Complements of Probability (3MIC MA Semester 5).

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