Application of Statistical Methods I & II

Organisation (Datapac):   Face to face: 51 hours   Homework: 170 hours   total load: 220 h

Organisation (TNM):   Face to face: 24 hours   Homework: 100 hours   total load: 124 h

ECTS (Datapac track) : 9

ECTS (TNM track) : 5

Objectives:
Machine Learning and Statistical Data Processing are today ubiquitous tools in several fields such as ICT, telecommunications, physics, geophysics, environment, biology, etc. The ever-increasing quantity of information requires the use of advanced statistical methods to make sense of raw data. This course aims at providing the fundamentals of decision theory and above all the practical bases for the implementation of state of the art statistical methods.

Keywords:
Statistical Data Analysis, decision theory, Unsupervised Methods, Supervised Methods

Prerequisites:

Program: -

Content:
- Introduction
- Preprocessing, Feature Extraction
- Statistical Data Analysis
- Bayesian Decision Theory
- Clustering
- Neural Networks
- Hidden Markov Models
- Project

Evaluation: Grading is as follows
Continuous exam (project)
Written exam
Oral exam

Lecturers: Dorizzi Bernadette, Sonia Garcia, Mounim El Yacoubi

Coordinator: Mounim El Yacoubi
Mounim.el_yacoubi@telecom-sudparis.eu
Communication theory and channel coding

**Organisation:**
- Face to face: 50 hours
- Homework: 50 hours
- total load: 100 h
- ECTS : 5

**Objectives:**
The course provides the students with an introduction to the theory of digital communications and error-correcting codes. The course is divided in two parts of five lectures each. Each lecture is followed by a tutorial class (1h30).

The students will have a basic knowledge in information theory and will be able to compute the capacity limit of simple binary memoryless channels. They will know how to choose the code parameters. They will understand the fundamentals of algebraic coding and decoding and convolutional coding and will be able to evaluate the performance of coded systems.

**Keywords:**

**Prerequisites:**
Reasonable level in mathematical analysis, probability theory, stochastic processes, and linear algebra. Background in abstract algebra may serve, but is not assumed.

**Program:**

**First Part: Digital Communications**

- Lecture 1: Introduction to system and refresher on mathematical tools
- Lecture 2: Baseband signals and channel modeling
- Lecture 3: Transmit signal modelling and detection theory
- Lecture 4: Detectors and performance for Gaussian channel
- Lecture 5: Detectors and performance for multipath channel (ML, ZF, MMSE, DFE)

**Second Part: Error-Correcting Codes**

- Lecture 6: Linear codes
  - Linear codes, generator matrix, parity-check matrix
  - Standard array and syndrome decoding
  - Hamming codes, Golay codes, etc.
- Lecture 7: Galois fields
  - General properties
  - Cyclic structure
  - Minimal polynomials
  - Factoring polynomials in Galois fields
- Lecture 8: Cyclic codes, BCH codes, RS codes
  - Polynomial codes, cyclic codes
  - BCH codes, BCH bound on minimal distance, Reed-Solomon codes
  - MDS codes
- Lecture 9: Algebraic decoding
  - Algebraic decoding – Peterson, Forney, Euclid or Berlekamp-Massey
  - Performance analysis of block codes under algebraic decoding
  - Application to real systems
- Lecture 10: Convolutional codes
  - Codes and encoders, minimal encoders, basic theorems
  - Maximum Likelihood Decoding (MLD) via Viterbi algorithm
  - Performance analysis of convolutional codes under MLD
  - Application to real systems

**Evaluation:** Grading is as follows

Written exam (2h)

**Lecturers:** Prof. Philippe CIBLAT

**References:**

**Coordinator:** Philippe CIBLAT
philippe.ciblat@telecom-paristech.fr
**Computer Networking**

**Organisation:**  
Face to face: 45 hours  
Homework: 45 hours  
**total load:** 90 h

**ECTS:** 5

**Objectives:**  
The objective is to provide a basic knowledge of Computer Networking issues and solutions. It includes:
- Mechanisms for reliable data transfer;
- Overview of commonly used networking technologies and TCP/IP Architecture.

**Prerequisites:** None

**Program:**

**Content:**
- Motivations and Problems for Computer Networking
- Architectural Model
- Layer, Protocol, Service, OSI Layers Functionalities
- Generic mechanisms (encapsulation, fragmentation, multiplexing, addressing...)
- Overview of TCP/IP Architecture
- Data Transfer Protocols
- Reliability, Flow Control, Switching
- Illustration with HDLC, IP and X25, TCP.
- Common technologies (Overview of TCP/IP Applications, Focus on LDAP Directory, DNS, IPv6)

**Evaluation:** Grading is as follows
- No continuous exam
- Written examination of approx. 2h

**Lecturers:** Badii Jouaber, Pascal Hennequin, Michel Gardie

**Coordinator:** Badii Jouaber  
**Badii.Jouaber@telecom-sudparis.eu**
Information theory and source coding

**Organisation:**  
Face to face: 50 hours  
Homework: 50 hours  
**total load:** 100 h

**ECTS:** 5

**Objectives:**

**Keywords:**

**Prerequisites:**

**Program:**
- Entropy, Conditional Entropy, Joint Entropy, Mutual information (2h Cours, 2h TD)
- Chain rule, Jensen Inequality, Data processing theorem (2h Cours, 2h TD)
- Sufficient statistics, Fano inequality, Convergences (2h Cours)
- Asymptotical equirepartition property (1h Cours, 1h TD)
- Kraft, Shannan, and McMillan theorems (2h Cours)
- Huffman coding, SFE coding, Arithmetic coding (2h Cours, 1h TD, 3h TP)
- JBIG, RLE, LZW (2h TD)
- Scalar quantization (2h Cours, 1h TD, 3h TP)
- Optimal quantization (1h Cours, 1h TD)
- Predictive quantization (2h cours, 1h TD)
- Vector Quantization (2h cours)
- Transform coding (2h Cours, 1h TD, 3h TP)
- DCT, KLT (1h cours)
- DWT (2h cours)
- JPEG, JPEG2000 (3h TP)
- Entropy, Conditional Entropy, Joint Entropy, Mutual information
- Chain rule, Jensen Inequality, Data processing theorem
- Sufficient statistics, Fano inequality, Convergences
- Asymptotical equirepartition property
- Kraft, Shannan, and McMillan theorems
- Huffman coding, SFE coding, Arithmetic coding
- JBIG, RLE, LZW
- Scalar quantization
- Optimal quantization
- Predictive quantization
- Vector Quantization
- Transform coding
- DCT, KLT
- DWT
- JPEG, JPEG2000

**Evaluation:** Grading is as follows

- N1 = written exam, 1st session.
- N2 = written exam, 2nd session.
- Final grade = sup(N1, N2)

**Lecturers:** Marco Cagnazzo, Béatrice Pesquet

**Coordinator:** Dr. Marco Cagnazzo  
cagnazzo@telecom-paristech.fr
Optimization Methods

**Organisation:**  
Face to face: 42 hours  
Homework: 80 hours  
**total load:** 122 h

**ECTS:** 6

**Objectives:**  
Acquiring some notions of optimization in continuous, discrete or mixed spaces and their relationship with concrete applications.

**Prerequisites:**  
Basic Calculus, Basic Algebra

**Program:** -

**Content:**  
- Dynamic programming  
- Branch and Bound methods  
- B&B and the Travelling Salesman problem : the Little algorithm  
- Linear Programming : the simplex algorithm  
- Unconstrained non-linear Programming : gradient methods, Newton method, quasi-Newton methods  
- Metaheuristics for hard optimization : Taboo Search, Evolutionary Computation, Simulated Annealing  
- Applications to Pattern Recognition : elastic distance, Dynamic Time Warping, gradient methods in neural networks, etc.

**Evaluation:** Grading is as follows  
Continuous exam (projects)  
Written examination

**Lecturers:** Sonia Garcia, Alain Petrowski, José Neto

**Coordinator:** José Neto  
[jose.neto@telecom-sudparis.eu](mailto:jose.neto@telecom-sudparis.eu)
Wireless Systems

**Organisation:**  
Face to face: 42 hours  
Homework: 42 hours  
**total load:** 84 h

**ECTS:** 5

**Objectives:**
- Master concepts related to architectures of RF receiver, multi-standard radio systems, Software Defined Radio (SDR) and cognitive radio.
- Master concepts related to RADAR.
- Master concepts related to radio propagation and modeling.
- Master concepts related to antennas.
- Become an expert in radio transmission area.
- Master the basic concepts thanks to practical experiments.

**Keywords:**
Radio and propagation, RF receiver, SDR, RADAR, Antenna, Measurements.

**Prerequisites:**
A background of first courses in electronic and microwaves is assumed.

**Program:**
- Radio architectures: emitter / receiver structures, SDR, RF sampling, Multi-standard receiver.
- RADAR principle: physical requirements, data signal and antenna.
- Radio propagation and modeling.
- Antennas, from simple to complex ones: wire antennas, aperture antenna, reflector antennas, array antennas, printed antennas.
- Measurements and practical labs: antennas, vector network analyze, spectrum analyzer, noise.

**Content:**

**Evaluation:**  
Grading is as follows
The assessment of this teaching unit is based on laboratory works, homework, oral presentation and written exam.
- NL = average (laboratory works + homework + oral presentation).
- N1 = written exam, 1st session.
- N2 = written exam, 2nd session.
- Final grade = \([NL + 2 \sup(N1, N2)] / 3\).

**Lecturers:** Muriel Muller, Christine Letrou, Alexandre Vervisch-Picois, Nel Samama, Ghalid Abib,  
Guest lecturers from Thalès, Sup'Com Tunis.

**References:**

**Coordinator:** Dr. Ghalid Idir ABIB  
ghalid.abib@telecom-sudparis.eu