# ESIEE Paris

# International Master of Computer Science
# "Computer Science for Intelligent Systems"

# Official program for years 2017 to 2019

### Embedded Real-Time Computing

- ▷ Real-Time Systems
- ▷ Embedded Operating Systems

### Signal and Systems

- ▷ Optimal Estimation and Control
- ▷ Distributed Control Systems

### Connectivity

- ▷ Networking
- ▷ Wireless Networks

### Algorithms

- ▷ Advanced Algorithms
- ▷ Optimization

### Machine Learning

- ▷ Machine Learning
- ▷ Deep Learning

### Digital Imaging

- ▷ Image Analysis
- ▷ Computer Graphics

### Safety

- ▷ Model Checking
- ▷ Synchronous Languages

### Management

- ▷ Intercultural Management
- ▷ Project Management

ESIEE PARIS

une école de la CCI PARIS ILE-DE-FRANCE

# First Year (E4)

## Period 1 Sept. 2017 → Nov. 2017

**Technical Courses (120 h)**

- ▷ **Networking**
- ▷ **Computer Architecture**
- ▷ **Signal and Systems**
- ▷ **Advanced Algorithms**

**Technical Project**

**Management Courses (30 h)**

- ▷ Intercultural Management and Communication

**French Language Courses (30 h)**

## Period 2 Nov. 2017 → Jan. 2018

**Technical Courses (120 h)**

- ▷ **Introduction to Image Analysis**
- ▷ Graph and Algorithms
- ▷ **Real-Time Systems**
- ▷ Optimal Estimation and Control

**Technical Project**

**Management Courses (30 h)**

- ▷ Corporate Finance and International Marketing

**French Language Courses (30 h)**

## Period 3 Jan. 2018 → May 2018

**Technical Courses (120 h)**

- ▷ **Wireless Networks**
- ▷ **Machine Learning 1**
- ▷ Optimization
- ▷ Model Checking

**Technical Project**

**Management Courses (30 h)**

- ▷ French Business Culture and Communication

**French Language Courses (30 h)**

## Period 4 May 2018 → Jul. 2018

Internship (3 months) or Project (2 months)

The technical courses that are in bold are mandatory courses, the other technical courses are elective courses that can be replaced by other courses proposed in other masters.

# Second Year (E5)

## Period 1 Sept. 2017 → Nov. 2018

**Technical Courses**

- ▷ Embedded Operating Systems
- ▷ Machine Learning 2
- ▷ Image Analysis
- ▷ Critical Application Development

**Management Courses**

- ▷ Corporate Profiling

**French Language Courses**

## Period 2 Nov. 2018 → Jan. 2019

**Technical Courses**

- ▷ Deep Learning
- ▷ Computer Graphics
- ▷ Computer Vision
- ▷ Distributed Control Systems

**Management Courses**

- ▷ Project Management and Innovation Management

**French Language Courses**

## Period 3 and 4 Jan. 2019 → Jun. 2019

Internship (6 months)

All technical courses are elective courses that can be replaced by other courses proposed in other masters.

# 1 Technical Course details – First year ('E4')

## Advanced Algorithms (Xavier Hilaire)

**Content :** Dynamic programming ; Divide and conquer ; Greedy algorithms ; Introduction to NP-completeness and approximation algorithms.

**Aim :** This course is a continuation to "Algorithms and Dada structures", and pertains specifically on problems solving. We present resolution methods from three widespread families of algorithms, all providing either exact, or approximate but guaranteed solutions within a given tolerance. Typical examples are provided in the case of stock management, transportations, or resource assignment problems.

### Bibliography


1. Dasgupta, Sanjoy and Papadimitriou, Christos H. and Vazirani, Umesh, Algorithms, http ://www.cse.iitd.ernet.in/ naveen/courses/CSL630/all.pdf
2. Sedgewick, Robert, Algorithms in C, 1990, Addison-Wesley Longman Publishing Co, Boston, MA, USA
3. Cormen, Thomas H. and Stein, Clifford and Rivest, Ronald L. and Leiserson, Charles E., Introduction to Algorithms, 2001, McGraw-Hill Higher Education


## Computer architecture (Eva Dokladalova)

**Content :** Computer architectures and performances ; Architecture of RISC processors ; Memory hierarchy ; YoDSP Programming

**Aim :** This course is a first introduction to computer architecture and its impact on performances. More precisely, we study how the structure of a program, once implemented on a particular architecture, can impact on performances. We present a design methodology that permits to obtain an optimized implementation (on RISC or DSP) of a program given its algorithmic specification

### Bibliography


1. John L. Hennessy and David A. Patterson. 2011. Computer Architecture, Fifth Edition : A Quantitative Approach (5th ed.). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.


## Signal and Systems (Arben Cela)

**Content :** Fourier and Laplace transforms ; Theory of convolution ; Sampling and reconstruction ; Dynamical Systems ; Integration methods ( Euler , Runge -Kutta , Adams) ; Stability ; Controllability, Observability.

**Aim :** Introduction to necessary mathematical tools for analysis of signal and dynamic systems. Different concepts such as stability, controllability and observability are introduced through different well known application examples. Mastering of the related Matlab/Simulink toolboxes, introduced through different applications, is another objectives of this course. The course also aims at introducing the basics of continuous-time and discrete-time signals and systems, such as impulse and frequency responses, the Fourier Transform, Fourier Series, Discrete Fourier Transform, Finite Fourier Transform, as well as the Z-Transform and the Function Transfer of a system. The course also involves, as part of it, the study and design of digital filters.

### Bibliography


1. K.J Aström and R. Murray, "Feedback Systems, An Introduction for Scientists and Engineers" Princeton University Press (http ://www.cds.caltech.edu/ murray/books/AM05/pdf/am08-complete_22Feb09.pdf)
2. Alan V. Oppenheim, Ronald W. Schafer, John R. Buck, DiscreteTime Signal Processing, PRENTICE HALL (1999)


## Networking (Lynda Zitoune)

**Content :** OSI model, layer abstraction ; Paquet switching (OSI layer 2) ; Routing (CISCO routers, OSI layer 3) ; WAN (Wide Area Network) and VPN (Virtual Private Network).

**Aim :** This course provides attendees with the most essential concepts from low to mid-level networking. The most widespread networking technologies are first introduced. It is then shown how these different technologies may be abstracted in the first layers of the OSI model. Routing is considered, with concrete example given on CISCO routers. Large networks, and their administration, are explained at last.

**Bibliography**

1. A. Tanenbaum : Computer Networks
2. W. R. Stevens : TCP/IP Illustrated, protocols

## Introduction to Image Analysis (Jean Cousty)

**Content :** Non-linear signal processing ; Erosion, dilation, closing, opening ; Skeletons ; Watershed segmentation, connected operators.

**Aim :** The aim of this course is to provide the fundamentals of mathematical morphology. We introduce new concepts in non-linear signal analysis, then explain the basic operators used in mathematical morphology and their main properties, and skeletonization. The problem of image segmentation is then considered, with the very popular watershed segmentation approach. Non-linear filtering and detection are illustrated on a wide variety of problems.

**Bibliography**

1. https ://perso.esiee.fr/ coustyj/EnglishMorphoGraph/

## Graph Algorithms (Jean Cousty)

**Content :** Graph traversal, connected components ; Shortest path ; Minimum spanning tree ; Maximal flow.

**Aim :** This course is an introduction to the most popular algorithms produced by graph theory, and used in pattern recognition, combinatorics, AI, and problem resolution amongst others. It aims to provide attendees with the ability to : formalize a given problem in terms of graphs ; identify whether the problem has a known solution or not ; and in case not, suggest a new algorithm and evaluate its complexity.

## Real-Time Systems (Yasmina Abdeddaïm)

**Content :** Real time scheduling algorithms ; Feasability analysis ; Optimality analysis ; Resource sharing ; Real-time Linux (RTAI).

**Aim :** This course is an introduction to scheduling for hard real-time systems. We introduce the task model, the classical scheduling algorithms, and feasibility analysis based on this model. Scheduling algorithms will be tested in practice on a real-time kernel.

**Bibliography**

1. G. C. Buttazzo Hard Real-time Computing Systems : Predictable Scheduling Algorithms And Applications (Real-Time Systems Series) Springer-Verlag TELOS Santa Clara, CA, USA,2004
2. rtai : https ://www.rtai.org/

## Optimal Estimation and Control (Arben Cela)

**Content :** Nonlinear optimization ; Dynamic programming ; Optimal estimation/observation of linear (discrete/continuous) systems ; Robust control and controller construction.

**Aim :** Formulation and resolve a general non-linear constrained optimization problem and illustrate it through simple and relevant examples from different application domains. Design and implement an optimal estimator and controller for dynamic system as well as an optimal scheduler for real-time systems. Special emphases will be put on mastering Matlab optimization toolbox as well as on relevant application domain such as energy optimization.

**Bibliography**

1. Frank L. Lewis and Suzhi Sham Ge, "Optimal and Robust Estimation", second edition, CRC Press, 2008.
2. Steven C. Chapra, "Applied Numerical Methods with Matlab for Engineers and Scientist" , third edition, Mc Graw Hill, 2012.
3. F. Borrelli, A. Bemporad, M. Morari, "Predictive Control for linear and hybrid systems", http ://www.mpc.berkeley.edu/mpc-course-material

## Machine learning 1 (Xavier Hilaire)

**Content :** Reminders on probabilities (PDFs, types of convergence, central limit theorem, marginalization, ...) ; Basics of classification. Naïve Bayes. LQDA. ; Parametric estimation : MLE, EM, MAP, Bayesian inference, maximum entropy ; Non-parametric estimation : Parzen windows, k-NN ; PAC learning. Learning from uniform convergence. ; The bias-complexity trade off. VC dimension. ; Structural risk minimization, and model selection.

**Aim :** This course covers the fundamentals of pattern classification, and provides a first taste of machine learning by introducing some of the its most important and fundamental results – those pertaining on generalization issues. We first explain Bayesian decision theory, and show how a given pattern classification problem may be expressed in terms of probabilities and distributions. We then study various well-known techniques usable to solve the problem raised as the outcome of formalization. Essential results of machine learning are presented next. Those address the following questions : what is learning ? How fast can a given algorithm learn ? How well will it generalize on unseen data ? Which model should be selected for a given problem or data set ? Practical sessions (of 2 or 4 hours) are organized after each chapter. Those involve programming using either scikit-learn (Python) or the Matlab ML toolbox.

### Bibliography


1. Bishop, Christopher M., Pattern Recognition and Machine Learning (Information Science and Statistics), 2006, Springer-Verlag New York, Inc., Secaucus, NJ, USA
2. Duda, Richard O. and Hart, Peter E. and Stork, David G., Pattern Classification (2Nd Edition), 2000 ,Wiley-Interscience
3. Cristianini, Nello and Shawe-Taylor, John, An Introduction to Support Vector Machines : And Other Kernel-based Learning Methods, 2000, Cambridge University Press ,New York, NY, USA
4. Mitchell, Thomas M., Machine Learning, 1997,McGraw-Hill, Inc.,New York, NY, USA,


## Optimization (Hugues Talbot)

**Content :** Linear programing ; integer programs and mixed integer-linear programs ; simplex algorithm ; branch and bound and cutting plane techniques.

**Aim :** This course provides an introduction to linear programming (LP), which is one of the easier and more versatile tool capable of modeling both objective functions and constraints. We study modeling ; the relationship between objectives and constraints ; the simplex algorithm ; duality and limit cases. In a second part, we study integer programming (IP), which is capable of modeling and solving most combinatorial problems, including NP-complete problems. This is essential in computer science because such problems are very common. Many examples are given. In a third part, we study transport problems, which is a class of IP problems that can be solved exactly and very efficiently. It is essential to be able to recognize such problems. In a last, short section, we provide an introduction to nonlinear, convex programming.

### Bibliography


1. Winston, W. L. Operations Research, Applications and algorithms, 3rd Ed. Duxbury Press, 1993.


## Model Checking (Yasmina Abdeddaïm)

**Content :** Reactive Systems Modeling ; Temporal Logics (CTL, LTL, CTL*) ; Model Checking Algorithms ; NuSMV Model Checker.

**Aim :** This course is an introduction to model checking, an automatic verification technique of concurrent and reactive systems. First we introduce the Kripke structure as a model of reactive concurrent systems, then the linear (LTL) and branching time (CTL) temporal logics used to model temporal specifications. Finally we present LTL and CTL model checking algorithms and the model checker tool NuSMV.

### Bibliography


1. Clarke, Orna Grumberg and Doron Peled, Model checking MIT Press Cambridge, MA, USA, 1999
2. NuSMV : http ://nusmv.fbk.eu/

# 2 Technical Course details – Second year ('E5')

## Embedded Operating Systems (Yasmina Abdeddaïm)

**Content :** The different tools used on the target system : kernel, uboot, rootfs, busybox ; Native compilation of a program on the target machine ; The tools used for Cross-compilation ; Develop/deploy an application to be used on the board ; Construction of a minimal image for a Raspberry Pi ; Customization of the image.

**Aim :** This course aims to present the methods and tools needed to build a GNU/Linux operating system using the source code. During the practicals, students have to build their own Linux operating system embedded on a Rasberry-pi 2.

## Distributed Control Systems (Arben Cela)

**Content :** Introduction to Distributed Control Applications ; Modeling and analysis of Distributed Control System ; Model Based Design of distributed real time application in Automotive Industry ; Applications of Distributed Real Time Systems.

**Aim :** The main objective of this course is to give the necessary tools for modeling, analysis and design of Distributed Control Systems. Classification of difference communication and calculation architectures help to achieve the modeling/analysis objectives and allows to point out the advantages/disadvantages w.r.t performance specification.

## Machine Learning 2 (Giovanni Chierchia)

**Content :** Linear regression, regularization, kernel trick, and linear model selection ; tree-based methods for regression and classification ; neural networks, and introduction to deep learning.

**Aim :** This course continues the study of machine learning concepts. We begin with linear regression, the fundamental starting point for modeling the relationship between a scalar dependent variable with one or more explanatory variables. We then move into the world of nonlinear modeling by considering tree-based methods for both regression and classification. Finally, we revisit neural networks in the context of deep learning. Each subject is illustrated in a laboratory session using simulated and real examples.

## Critical application development (Yasmina Abdeddaïm)

**Contents :** Synchronous paradigm ; Esterel Synchronous Language ; Lustre Synchronous Language ; SCADE software.

**Aim :** Synchronous languages are used for the development of embedded reactive systems which are at the same time complex and critical systems. These languages are currently used successfully in industry, for example, EADS uses the software SCADE, based on the language Lustre, to program the embedded software flight control of Airbus. In this course, the fundamental principles of synchronous programming are presented then the we present the language Lustre and then we will learn the fundamental of the software SCADE and use it in a project.

## Computer Vision (Xavier Hilaire)

**Contents :** 2D and 3D projective transformations ; Camera calibration ; Epipolar geometry ; Dense and spare stereo vision algorithms ; Trifocal tensor.

**Aim :** This course introduces the fundamentals of computer vision : projective geometry, homographies, and single view cameras are first deeply studied to provide good mathematical grounds to attendees. Mathematical notions on eigenvalues, SVD, least squares, and constrained optimization will be recalled. Stereo vision and epipolar geometry are presented next, along with classical point matching algorithms and some efficient 3D object recognition algorithms. Extension to n cameras, and related open problems, are presented at last. The course includes a number of practical lab sessions on OpenCV, during which students will learn to : calibrate cameras, build a panoramic view from several overalaping shots, recognize and track a 3D object.

## Computer Graphics (Nabil Mustafa)

**Contents :** Android development environment ; getting and using sensor data in Android systems ; OpenGL ES 3.0 ; shading and texturing in OpenGL ES 3.0 using GLSL ES.

**Aim :** OpenGL Embedding Systems (ES) is an open source API that provides a strong and viable interface for the stimulation of software and graphics for Android games. It paves the way to making complete games for Android devices solely using the Android SDK. The aim of this course is to learn OpenGL ES 3.0, and its use in Android systems in development of graphics games, with the sensory inputs given by accelerometers, gravity sensors, gyroscopes, and rotational vector sensors present in mobile devices.