ESIEE PARIS

MASTER OF ENGINEERING

COMPUTER SCIENCE MAJOR

1st Year - Common Core

1st Semester	ECTS
1- Signal and Systems **Aim:** The objective of these notes is to give an accessible introduction to signals and systems for electrical engineering, computer engineering, and computer science. **Content:** - Fundamentals of continuous-time/discrete-time signals: (a) Introduction to Fourier and Laplace transforms; (b) theory of convolution and the concept of transfer function; (c) sampling and reconstruction - Essentials of feedback control: (a) representation of dynamical systems (state-space, input-output); (b) basic feedback loops and more abstract representations; (b) structural properties (controllability, observability); (c) stability (internal, input-output) and sensitivity (load disturbance, noise); (d) control algorithms and methodologies (PID, state feedback, pole placement, observers) - Dealing with uncertainty and systems' limitations (measurement noise, actuator	3
2- Object-Oriented Programming **Aim:** This course explains the main principles and advantages of object-oriented programming around Java. It assumes attendees are already familiar with a procedural programming language, such as C, and provide them with the necessary background to write and test a complete application under Linux or Windows in Java. **Content:** - Introduction to Object-Oriented Languages (OOL) - Inheritance and abstraction. Exceptions. - Collections and generics - I/O operations, threads. - Packages from JDK, commands. saturation, process dynamics)	3
3- Computational Geometry **Aim:** This course is an introduction to computational and digital geometry. Computational geometry is a realm devoted to the study of efficient algorithms and their associate data structures for solving geometrical problems in terms of basic objects such as points, lines, polygons, etc. Digital geometry specially deals with digitized objects in digital images. Conceivable applications for both include computer graphics, image analysis, robotics, geographic information systems, and computer-aided engineering. **Content:** - Spatial decompositions - Geometric searching - Convex hull algorithms - Geometrical simplification	3

4- Computer Architecture **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. **Content:** - Computer architectures and performances - Architecture of RISC processors - Memory hierarchy	3
5- Graph Algorithms **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 **Content:** - Graph traversal, connected components - Shortest path - Minimum spanning tree - Maximal flow	3
6- Operating Systems **Aim:** This course aims to provide the basic working principles of any modern operating system. We outline the various components which a computer is made of,, then focus on tasks, memory, and disks, and the various problems that they raise. We explain some well-known solutions to these problems, evaluate their efficiency, and illustrate their action with concrete examples for Unix, Linux and Windows NT/XP operating systems. **Content:** - Process and scheduling - Process communication - Memory management - Disks and file systems	3
7- Mathematical Morphology **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. **Content:** - Non-linear signal processing - Erosion, dilation, closing, opening - Skeletons - Watershed segmentation, connected operators	3
8- Networking **Aim:** This course provides attendees with the lost 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. **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)	3

9- French Language	2
10- French Culture and Intercultural	2
11- Management - Marketing - Finance - IT law	2
2nd Semester	
1- Advanced Algorithms **Aim:** This course is a continuation to the “Graph Algorithms” course, 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 **Content:** - Dynamic programming - Divide & conquer - Greedy algorithms	3
2- Optimization **Aim:** This course is an introduction to the area of linear optimization. Students will learn basic and advanced theory on the topic, and applications. **Content:** - Simplex algorithm - Branch & bound, and A* - Integer programming	3
3- Pattern Recognition, Machine Learning **Aim:** This course introduces the fundamentals of statistical pattern recognition and machine learning. We first explain Bayesian decision theory, and show how a given PR 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. Generalization theory, and elements of machine learning are introduced at last. Examples are provided on real problems, most of which arise from medical imaging or sensoring. **Content:** - Bayesian decision theory - Maximum-likelihood based methods (naïve Bayes, EM, HMM) - Linear discriminant analysis - Multilayer neural networks - Introduction to Support Vector Machines	3
4- Theory of Information and Applications **Aim:** These lectures deal with statistical information processing and theory. The course first introduces estimation theory, with the fundamendal Cramer-Rao bound associated with Fisher information. Then we deal with classical information theory: ayesia entropy, Kullback-Leibler divergence and present the source and channel coding theorems, with applications in compression and data transmission. The lectures are illustrated with labs in estimation concepts and on an implementation of a compression algorithm. **Content:** - Estimation theory (maximum likelihood, ayesian approaches) - Entropies and divergences - Source coding (compression) - Channel coding	3

5- Optimal Estimation and Control **Aim:** The objectives of these lectures are twofold: first, to give a better comprehension of the emerging dynamics induced by systems' interconnections (limitations, "trade-offs", etc.), and second to introduce necessary tools to optimize the dynamic behavior of discrete/continuous linear systems in the presence of uncertainty and/or of various constraints on the dynamics. Different problems such as optimal estimation and observation and optimal/robust control will illustrate the theoretical part. The lectures will end with basic notions and tools in robust control as well as with various discussions on the methods to be used in constructing appropriate controllers. Various examples (networked control systems, synchronization movement over networks) will complete the presentation. **Content:** - Interconnections and dynamics. Case studies and discussions - Nonlinear optimization: constrained nonlinear optimization, Lagrange multipliers - Dynamic programming: principle of optimality, dynamic programming, discrete/continuous LQR - Optimal estimation/observation of linear (discrete/continuous) systems - Robust control and controller construction	3
6- Model Checking **Aim:** This course is an introduction to model checking, an automatic verification technique of concurrent and reactive systems. In the first part of the course we study the kripke structure as a model of reactive concurrent systems, then we introduce the linear and branching time temporal logics and model checking algorithms for these logics. Finally we describe how to represent **Content:** - Reactive Systems Modeling - Temporal Logics (CTL, LTL, CTL*) - Model Checking Algorithms. - Binary Decision Diagram - Symbolic Model Checking	3
7- Real Time Systems **Aim:** This course is an introduction to scheduling for hard real-time systems. We introduce the task model and scheduling algorithms, and feasibility and optimality analysis based on this model. Scheduling algorithms will be tested in practice on a real time kernel. **Content:** - Real time scheduling algorithms (feasibility analysis, optimality analysis, resource sharing) - Real time Linux (RTAI)	3
8. French Language	2
9. Management **Content:** - Strategy - Entrepreneurship - Change management - Human ressources	2
10. Project	5
Total ECTS	**60**

2nd Year - Computer Imagery Option

1st Semester	ECTS
1. Image Analysis **Aim:** This course covers the most popular techniques used in image analysis. We study the fundamental problem of image segmentation, which consists in separating objects in the foreground of a given image from its background, and also separating objects one to each other. This problem is formulated both in the classical framework of optimization (functional minimization), and in the frequency domain for textured segmentation. Various measurements techniques (such as perimeter, surface, volume, or diameter estimation for instance) are then presented. Direct applications of wavelet theory and Fourier analysis are also considered. **Content:** - measurements (2D, 3D) - segmentation based on functional minimization - application of linear methods (wavelet, FFT)	3,5
2. Image Processing	3,5
3. Image Synthesis **Aim:** This course introduces various theoretical and practical aspects of computer graphics. We study 3D modeling, real time rendering techniques (OpenGL), but also more sophisticated strategies (global enlightenment techniques such as ray shooting, photon mapping, or simulation of natural phenomenons). We also study advanced real-time techniques (occlusion mapping), and games graphical engines, such as Halo 3, or problems dealing with rendering in multimedia post-production. **Content:** - Illumination models, reflections models (phong, Catmull klark...) - Graphic pipeline, multitexturing - Real time techniques (illumination maps, ambiant occlusion, env maps...) - Global illumination algorithms : photon mapping, metropolis, radiosity... - PRT	3,5
4. Hardware for Parallel Image Processing **Aim:** These lectures are a continuation to “Computer Architecture” (given in common core), and emphasizes on parallelisation issues in a hardware standpoint. **Content:** - Introduction to parallelism (SIMD, MIMD, PRAM models. Message passing based architectures. Introduction to PVM and MPI) - Intraprocessor parallelism (RISC, CISC, superscalar, VLIW, SoC architectures) - Multicomponent parallelism (multi-DSP, FPGA)	3,5
5. Computer Vision **Aim:** This course introduces the main ingredients of computer vision, such as 2D and 3D projective geometry, and computer vision problems with one to n cameras. Some extensions to the field of computer vision, such as augmented or virtual reality, are also presented. At last, an overview of current challenges and commercial applications is given. **Content:** - 2D and 3D projective transformations - Camera calibration - Epipolar geometry - Trifocal tensor - Augmented Reality	3,5

6. Applications I (project) **Aim:** **Content:** - Biomedical imaging - Geographical Information Systems	3,5
7. Applications II (project) **Aim:** **Content:** - Games and multimedia - Virtual and augmented reality	3,5
8. French Language	2
9. Management **Content:** - Intercultural management, - Team-building, - Leadership, - Inter-personal skills,	2
10. Project Management and Innovation **Content:** - International project management - Innovation	2
2nd Semester	
Final Project	30
Total ECTS	**60,5**

2nd Year- Option: Embedded & Distributed Systems

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<tr><th>1st Semester</th><th>ECTS</th></tr>
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1- Automata and Applications

Aim: The aim of this lecture is to provide to students the theory of automata and some of their applications. In the first part, we introduce the basic theory of finite automata and its application to indexing structures and pattern matching. In the second part, we show how quantitative information can be added to finite automata, we present timed automata an extension of finite automata used for checking real time properties of distributed systems.

Content:
1. Finite Automata and Indexing Structures
- Words, regular languages and automata
- Operations on languages and automata : set operations, product, star
- Determinization, Minimization
- Quotient of automata
- Borders, Periods
- Suffix automaton, Suffix trie
- Compaction, Minimization of acyclic automata
- Forbidden minimal words.

2. Timed Automata and Model Checking
- Modeling using timed automata
- Clock Regions
- Clock Zones
- Difference Bound Matrices
- UPPALL Model Checker
- Timed game automata

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2. Wireless Networks, Routing, Sensors

Aim:

Content:

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3. Distributed Algorithms

Aim: A distributed system is a collection of individual computing devices that can communicate with each other. This very general definition encompasses a wide range of modern computer systems, ranging from tightly-coupled shared memory multiprocessor, to a local area cluster of workstations, to the Internet. This course focuses on systems at the more loosely coupled end of this spectrum. In such distributed system, generally each processor (entity) has its own semi-independent agenda, but for various reasons, including sharing of resources, availability and fault tolerance, processors need to coordinate their actions. Although distributed systems are highly desirable, putting together a properly functioning system is a difficult task. Most of the fundamental difficulties are introduced by the limited local view and the possible failure of an entity. The aim of this course is to present a large body of theory about distributed algorithms for the design of distributed applications.

Content:
- Models of Distributed Systems and Communication Protocols
- Logical Time and Synchronous Network Algorithms
- Mutual Exclusion in General Networks
- Leader Election in Named and Anonymous Networks
- Fault Tolerance and Self-stabilizing Algorithmsnet ...

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4. Real Time Distributed Systems **Aim:** This course will address the problem of distributed applications in real time context. We present the methods of design and implementation of distributed algorithms and evaluate their performance. **Content:** - Distributed Architectures - Multiprocessor Scheduling - Algorithm Architecture Adequation Methodology - Parallel computing for real time systems - Communication Models , ex :CAN, Ether	3,5
5. Distributed Control Systems **Aim:** **Content:** - Optimal scheduling for distributed control applications - Distributed control under resource constraints - Off line optimal scheduling/control - On line optimal scheduling/control	3,5
6. Model-driven Design and Development **Aim:** The aim of this lectures is to study the industry standard Unified Modeling Language (UML) for specifying discrete event systems. We present a real-time extension of UML for designing embedded systems and develop real-time applications using the UML-compliant design automation tool : Rhapsody. **Content** - UML, UML-RT - Structure Diagram (class diagram, object diagram) - Behavior Diagram (statecharts) - Software Component and Aspect-oriented Programming	3,5
7. Distributed Applications Development **Aim:** **Content:** - Distributed Objects (CORBA et RTCorba) - Data-Distribution Service for Real-Time Systems (DDS)	3,5
8. French Language	2
9. Management **Content:** - Intercultural management, - Team-building, - Leadership, - Inter-personal skills,	2
10. Project Management and Innovation **Content:** - International project management - Innovation	2
2nd Semester	
Final Project and thesis	30

Total ECTS	**60,5**