

SHAKE THE FUTURE.



# MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

## CONTROL AND ROBOTICS

### SIGNAL AND IMAGE PROCESSING

YEAR 1  
AUTUMN SEMESTER

PROGRAMME SUPERVISORS:  
GUY LEBRET, OLIVIER-HENRI ROUX

# SIGNAL PROCESSING

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 AUTUMN SEMESTER

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LEAD PROFESSOR: Eric Le Carpentier, [eric.le-carpentier@ec-nantes.fr](mailto:eric.le-carpentier@ec-nantes.fr)

## Objectives

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- To interpret the spectral representations of signals
- To understand the time sampling of signals (sample rate, anti-aliasing filter etc.)
- To model a system using the transfer functions language
- To model a system using the state space language
- To switch from one representation to the other
- To link the physical phenomena to the parameters of these representations (stability, response velocity etc.)
- To simulate these mathematical representations with adapted scientific software tools (Matlab, Simulink)

## Course contents

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- Analysis of continuous-time and discrete-time signals
  - Fourier, Laplace and z transforms
  - Sample, hold, quantization, Shannon theorem
- Modelling of continuous-time and discrete-time linear time invariant (LTI) systems
  - Transfer function, state space representation
  - Poles, zeros, stability
  - Time response, frequency response
  - Sampling
  - Simulation (Matlab Simulink)
  - First-order and second-order systems
- Design of an actual digital control implementation
  - Analog to Digital Converter, Digital to Analog converter
  - Sample and hold
  - Link with the previous mathematical representations
- Lab work
  - Music: from the sound signal to the score
  - Tide Periodicities
  - Spacecraft control simulation

## Course material

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- Modern Signals and Systems, H. Kwakernaak, R. Sivan, Prentice Hall.
- Signals and Systems, R. Baraniuk,  
<http://www.eng.ucy.ac.cy/cpitris/courses/ece623/notes/SignalsAndSystems.pdf>
- Signal processing. Introduction to signals and systems theory, E. Le Carpentier,  
<https://hippocampus.ec-nantes.fr/mod/resource/view.php?id=9179>

## Keywords

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Signal, System, Sampling, Filtering

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	14 hrs	0 hrs	18 hrs	0 hrs	2 hrs

# CLASSICAL LINEAR CONTROL

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 AUTUMN SEMESTER

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LEAD PROFESSOR: Guy Lebret, [guy.lebret@ec-nantes.fr](mailto:guy.lebret@ec-nantes.fr)

## Objectives

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Review the fundamentals of classical control for linear systems and provide a control methodology starting from the open loop analysis of the system to be controlled to the synthesis of a closed loop using classical PID type controllers (one degree of freedom controllers) which can be combined with a feedforward part (two degrees of freedom controllers).

## Course contents

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- Description of SISO linear systems through the transfer function
- Analysis of behaviour (poles/zeros, first/second/more general systems, time domain/frequency domain responses etc)
- Definition the Control objectives (stability/performance, tracking/regulation)
- Nominal/robust stability (Routh, Nyquist criteria, stability margins).
- Nominal/robust performance and the unavoidable trades off between stability and performance.
- Synthesis of PID type controllers, using frequency approach tunings, in a classical closed loop (one degree of freedom controller strategy).
- Possibility of introducing a feedforward contribution which tries to “invert” the first closed loop obtained (two degrees of freedom controllers).

After completing this course, the students will be able to:

- Analyse the dynamic behaviour of a SISO linear system
- Design a PID type controller as an example of a feedback controller
- Design a feedforward controller to increase tracking performance

## Course material

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Recommended texts: course notes will be provided by the lecturer.

Further reading:

- “Modern Control Systems”, R.C. Dorf and R.H. Bishop, Prentice Hall, 2011.
- “Control Systems Engineering”, N. S. Nise, John Wiley & Sons, 2011.
- “Control system design”, G.C. Goodwin, S.F. Graebe and M.E. Salgado, Prentice Hall, 2001.
- “Multivariable Feedback Control Analysis and Design”, D.S. Skogestad and I. Postlethwaite, Wiley, 2005.

## Keywords

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Classical control, SISO Linear Systems, two degree of freedom controllers, PID, lead lag controllers

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	5	22 hrs	6 hrs	4 hrs	0 hrs	2 hrs

# ARTIFICIAL INTELLIGENCE

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 AUTUMN SEMESTER

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LEAD PROFESSOR: Didier Lime, [didier.lime@ec-nantes.fr](mailto:didier.lime@ec-nantes.fr)

## Objectives

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The goal of this course is to present how a computerized agent can learn from its environment and find strategies to achieve well-defined goals.

## Course contents

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The first part covers basic path-finding, which is further extended to account for non-determinism, probabilistic outcomes, partial observability, and the presence of other agents. The second part deals with the specific problems of supervised learning and reinforcement learning.

After completing this course, the students will be able to:

- use and implement graph-based strategy search, in particular using Markov decision processes
- use and implement decision tree and artificial neural network learning (including the basics of deep learning)
- use and implement several simple flavors of reinforcement learning.

Assessment: 100% final examination

## Course material

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S. Russel, P. Norvig. Artificial Intelligence: A Modern Approach (3rd ed). Pearson, 2009.

## Keywords

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Path-finding, Markov Decision Processes, games, Neural networks, decision trees, supervised learning, reinforcement learning.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	16 hrs	4 hrs	12 hrs	0 hrs	2 hrs

# EMBEDDED ELECTRONICS

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 AUTUMN SEMESTER

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**LEAD PROFESSOR:** Olivier H. Roux, [olivier-h.roux@ec-nantes.fr](mailto:olivier-h.roux@ec-nantes.fr)

## Objectives

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At the end of the course the students will be able to:

- understand different synchronous or asynchronous architectures of embedded systems
- interface a microcontroller with a simple environment (LED, motor) and write a programme to control it;
- use VHDL to create the logic circuit used to configure a Complex Programmable Logic Device (CPLD).

## Course contents

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The first part of the course deals with interfacing a microcontroller:

- interfacing an Arduino with an environment composed of LED, buttons and a motor
- write programmes carrying out simple automatisms controlling this environment

The second part of the course introduces the configuration of a CPLD:

- VHDL Language
- use VHDL to create the logic circuit used to configure a Complex Programmable Logic Device
- control an environment with a Xilinx CoolRunner-II CPLD

## Course material

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- Philip Koopman, Better Embedded Software Systems, Drumndrochit Education LLC, 2010
- Volnei A. Pedroni, Circuit Design and Simulation with VHDL, PH, 2011

## Keywords

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CPLD, Microcontroller, Arduino, VHDL

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	10 hrs	2 hrs	20 hrs	0 hrs	2 hrs

# SYSTEMS IDENTIFICATION AND SIGNAL FILTERING

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 AUTUMN SEMESTER

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LEAD PROFESSOR: Saïd Moussaoui, [said.moussaoui@ec-nantes.fr](mailto:said.moussaoui@ec-nantes.fr)

## Objectives

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After completing this course, the students will be able to:

- specify all the desired properties of a linear filter
- design a linear filter fulfilling the specifications and apply it to a real signal
- give an input-output representation of a system based on observed data
- calculate the parameter of a model and validate on measurement data

## Course contents

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Signal filtering is a basic operation in signal processing which allows, for instance, undesired content to be deleted. The first part of this course deals with methods to design analog and digital filters and their application for the processing of real signals. The second part of the course focuses on experimental modelling of systems based on linear models. It provides a detailed description of the signal identification chain from data acquisition to model validation.

### 1. Signal filtering

- principles of linear filtering, filter characterization in the frequency domain
- analog filter synthesis
- digital filter synthesis (FIR, IIR)

### 2. System identification

- system modelling and identification methodology
- non-parametric identification models and methods
- review of linear models for system modelling (ARX, ARMAX, OE)
- parameter estimation methods (least squares, instrumental variable, maximum likelihood)

### 3. Applications

- audio signals filtering
- use of the system identification toolbox
- electromechanical system identification

## Course material

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- L. Ljung, System identification, Theory for the user, Prentice Hall, Englewood Cliffs, 1987
- T. Soderstrom and P. Stoica, System identification, Prentice Hall, 1989
- H. Kwakernaak and R. Sivan, Modern signals and systems, Prentice Hall, Englewood Cliffs, 1991

## Keywords

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Dynamical system, system modelling, identification, signal filtering, filter synthesis

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	12 hrs	10 hrs	10 hrs	0 hrs	2 hrs



# EMBEDDED COMPUTING

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 AUTUMN SEMESTER

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**LEAD PROFESSOR:** Mikaël Briday, [mikael.briday@univ-nantes.fr](mailto:mikael.briday@univ-nantes.fr)

## Objectives

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At the end of the course the students will be able to:

- understand the architecture of a microcontroller;
- design a low-level driver to access a peripheral of a microcontroller and deal with microcontroller interrupts;
- design a bare metal application.

## Course contents

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The first part of the course deals with the software environment for deeply embedded systems:

- cross compiler: bit operations, memory model, common C design rules, low level C and assembly specific attributes
- link script to declare the memory model to the application
- debugging with a JTAG probe (breakpoints, memory watch, etc)

The second part introduces hardware peripherals of a microcontroller to interact with the environment:

- standard GPIO
- timers
- serial communication peripherals
- interrupts

The third part of the module focuses on the design of a bare metal application, including concurrent execution of both software and hardware parts.

## Course material

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- Philip Koopman, Better Embedded Software Systems, Drumndrochit Education LLC, 2010
- D. Patterson & J. Hennessy, Computer Organization and Design – ARM Edition, Morgan Kaufmann, 2017

## Keywords

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Microcontroller, low level C programming, bare metal application.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	12 hrs	4 hrs	16 hrs	0 hrs	2 hrs

# MODERN LANGUAGES - FRENCH

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 - AUTUMN SEMESTER

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LEAD PROFESSOR: Silvia Ertl – [silvia.ertl@ec-nantes.fr](mailto:silvia.ertl@ec-nantes.fr)

## Objectives

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The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources. Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

## Course contents

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Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Giving and obtaining factual information:
  - personal information (e.g. name, address, place of origin, date of birth, education, occupation)
  - non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)
2. Establishing and maintaining social and professional contacts, particularly:
  - meeting people and making acquaintances
  - extending invitations and reacting to being invited
  - proposing/arranging a course of action
  - exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and

environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:

- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases
- ordering food and drink

## Course material

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Course material: Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

## Keywords

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reception (listening and reading), production (spoken and written), interaction (spoken and written), knowledge, skills, linguistic competence, sociolinguistic competence, pragmatic competence, register, cultural differences, non-verbal communication

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

# MODERN LANGUAGES – CULTURAL AND COMMUNICATIONAL ENGLISH

CONTROL AND ROBOTICS – SIGNAL AND IMAGE PROCESSING  
YEAR 1 - AUTUMN SEMESTER

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LEAD PROFESSOR: Spencer Hawkridge- [spencer.hawkridge@ec-nantes.fr](mailto:spencer.hawkridge@ec-nantes.fr)

## Objectives

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Introduction to Cultural and Communicational English:

- Understand the general concepts of communication English (different levels of language, etc.)
- Build a communicational project
- Develop strategies for enhanced interaction
- Organize, lead and participate in discussions, interviews and meetings
- Behavioral skills in an inter-cultural environment:
- Strengthen engagement and level of conviction
- Develop a capacity to explain and argue
- Acquire notions of corporate culture and values
- Enhance team work

## Course contents

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Cultural and Communicational English: exercises to explore in practice the areas of culture and communication

Inter-cultural project (for example, documentary project, publishing project: construct a work of fiction or of educational value and experience the complete publishing process)

## Course material

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Written and televised press, information and digital tools, general documents business environment and company strategies.

Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle). Our own eZoomBook template for the Intercultural project.

## Keywords

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Culture and communication, inter-cultural environment, team-building, digital tools, etc.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	30 hrs	0 hrs	0 hrs	2 hrs