CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2021-2022

YEAR 2

CONTROL AND ROBOTICS

EMBEDDED REAL TIME SYSTEMS

PROGRAMME SUPERVISOR(S):
Didier LIME

YEAR 2 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
APLA	Automated Planning	4
CONF	Conferences	-
EMBED	Energy-aware Embedded Systems	4
ESS	Embedded Software Systems	4
FMOV	Formal Modelling and Verification	4
MEREC	Project	2
PN	Petri Nets	4
SCHED	Real Time Scheduling	4

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE3	Cultural and Communication English	4
ESP3	Spanish Language	4
FLE3	French Language	4

YEAR 2 - Spring Semester

CORE COURSES

Course code	Title	ECTS Credits
THESIS	Internship / Thesis project	30

Automated Planning [APLA]

LEAD PROFESSOR(S): Didier LIME

Objectives

The objective of this course is to obtain a working knowledge of problems and solutions linked to strategy search in complex discrete event systems.

Course contents

Using graphs and game theory we will strudy how to reach simple objectves in simple to more realistic environments. This includes:
- graph search
- non determinism
- Markov decision processes
- partial observation
- game tree search: minimax, negamax, alphabeta, Monte Carlo Tree Search

Several algorithms studied will be implemented in practice during lab sessions.

Course material

- Stuart Russel and Peter Norvig, Artificial Intelligence: A Modern Approach (3rd edition), Prentice-Hall, 2010.
- Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An introduction, MIT Press, 1998.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	18 hrs	12 hrs	0 hrs	0 hrs	2 hrs

Conferences [CONF]

LEAD PROFESSOR(S): Didier LIME

Objectives

This course is devoted to general conferences that may be given during the year.

Course contents

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	-	20 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Energy-aware Embedded Systems [EMBED]

LEAD PROFESSOR(S): Audrey QUEUDET

Objectives

The main objective of the course is for students to become familiar with the typical problems and constraints that arise when designing and developing embedded systems.

The first part of the course aims at acquiring an understanding of the basic Linux operating system, highlighting areas of concern for embedded Linux systems development. We will address the testing, booting and configuring of embedded Linux systems including embedded cross-development and target board considerations.

The second part of the course focuses on embedded real-time systems which have energy limitations. The issue particularly concerns small electronic devices, such as wireless sensor nodes and cyber-physical objects. The objective is to present their special operational features, and accordingly demonstrating the necessity of implementing new techniques of real-time scheduling and power management.

Course contents

The course will be composed of the following parts:

- Introduction to embedded systems: Challenges of embedded systems, embedded system design process, Modelling of real-time embedded systems
- Linux operating system: strengths and weaknesses of Linux in embedded systems, Linux embedded market overview, Linux filesystem overview, configuring, (cross)compiling and booting a Linux kernel, toolchain generation tools, Linux tools for embedded systems (bootloaders, optimized libraries, Busybox)
- Setting a simple Buildroot-based embedded Linux: toolchain configuration, package selection, system configuration, kernel and bootloader configuration, building root filesystem image, customization.
- Real-time solutions for Linux: real-time patchs, Xenomai architecture.
- Designing autonomous embedded systems: hardware and software components of an autonomous system, harnessing ambient energy for embedded systems
- Classical approaches to minimize energy consumption in embedded systems: dynamic power management, DVFS (Dynamic Voltage Frequency Scaling)
- Real-time scheduling and power management in autonomous systems that rely on renewable energy harvesting

Course material

- Pierre Ficheux, Linux embarqué : Mise en place et développement, Eyrolles, 2017
- Maryline Chetto and Audrey Queudet, Energy autonomy of real-time systems, ISTE Press - Elsevier, 2016

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	20 hrs	4 hrs	6 hrs	0 hrs	2 hrs

Embedded Software Systems [ESS]

LEAD PROFESSOR(S): Jean-Luc BECHENNEC

Objectives

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

- Understand how an embedded operating system works
- Use advanced C programming
- Use formal methods in the design process

Course contents

Introduction to ESS
- Specificities of embedded software systems
- Embedded / Real-time operating systems

RTOS internals
- Execution context
- Processor modes
- System calls
- Interrupt handling
- Context switching

Advanced C programming
- Datatypes and memory mapping. Type casting
- Pointers, pointer arithmetics
- Assembly language and execution context
- Mixing C and assembly language

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	14 hrs	4 hrs	12 hrs	0 hrs	2 hrs

Formal Modelling and Verification [FMOV]

LEAD PROFESSOR(S): Didier LIME

Objectives

The aim of this course is to provide an understanding of the benefits and challenges of formal modelling and verification for complex systems, as well as the ability to use existing verification tools in practice.

Course contents

In this course, we study how complex dynamic systems and the properties they should satisfy can be modelled using mathematically-grounded formalisms. Using finite state machines and temporal logics we investigate algorithms that perform automatic verification (model-checking) and, to some extent, synthesis on those systems. We study, in particular, the case of timed systems, in which the occurrence of discrete events is subject to timing constraints. The corresponding formalisms are very useful to assert the soundness of real-time embedded systems. The theoretical aspects of the course will be illustrated in practice, using the model-checker software tool Uppaal.

Course material

Chistel Baier and Joost-Pieter Katoen. Principles of Model Checking. MIT Press. 2008

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	6 hrs	8 hrs	0 hrs	2 hrs

Project [MEREC]

LEAD PROFESSOR(S): Malek GHANES

Objectives

The purpose of this project is for the student to apply the theories and techniques studied during the courses, according to his/her career plan. It is, therefore, either a technical project for an industrial application, or an introduction to research to consider a research profession.

Course contents

This project can be either a technical project or an initiation to research: latest developments, proposals, experiments, analysis and prospects etc.
It is an extended individual project (including scientific support, bibliography, scientific study)

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	2	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Petri Nets [PN]

LEAD PROFESSOR(S): Olivier Henri ROUX

Objectives

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

- Model a reactive and concurrent system with a Petri Net
- Verify the boundedness, the reachability of a state and the coverability of Petri Nets
- Model a real time system with a Time Petri Net (TPN)
- Compute the state space of the TPN
- Model a property with an observer
- Express and verify a timed property with the logic TCTL (Timed Computation tree logic)
- Manipulate a Petri Net model checker

Course contents

Part 1: A Petri net, also known as a place/transition (PT) net, is one of several mathematical modelling languages for the description of distributed and embedded systems. It is a class of discrete event dynamic system. This course provides an introduction to Petri Nets. Firstly, after a set of basic definitions, a classification of Petri nets is proposed. Then, properties are exhibited whether they are dependant of the initial marking or not. A general algorithm is then stated to compute a set of properties. The last section covers the implementation of theoretical concepts, established above, in a functional language.

Part 2: In real-time and embedded systems, the correctness depends on the output and also on the time in which this output is produced. Therefore, the verification of such systems requires the determination of quantitative temporal properties, besides qualitative properties associated with its logical correctness. Time Petri Net (TPN) models have been widely used for the specification and verification of real-time and embedded systems. Semantics, expressiveness and properties of TPN are exhibited. The last section addresses reachability analysis for Time Petri Nets based on the state space computation.

Course material

- Wolfgang Reisig, Understanding Petri Nets - Modeling Techniques, Analysis Methods, Case Studies, Springer-Verlag, 2013
- Louchka Popova-Zeugmann, Time and Petri Nets, Springer-Verlag, 2013

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	6 hrs	8 hrs	0 hrs	2 hrs

Real Time Scheduling [SCHED]

LEAD PROFESSOR(S): Maryline CHETTO

Objectives

The course deals with the problem of achieving timing correctness in real-time systems, which means guaranteeing that the system reacts within the timing requirements through an adequate real-time scheduler. The course describes the most common scheduling methods for periodic tasks and aperiodic tasks, resource access control protocols and overload handling approaches.

Course contents

The course will be composed of the following parts:

- Introduction: Concepts on real-time computing, Role of the scheduler in the Real-Time Operating System, Modelling of real-time tasks, Metrics for performance evaluation
- Scheduling periodic tasks: Fixed priority, Dynamic priority, Scheduling with precedence constraints, Schedulability testing, processor demand analysis
- Aperiodic task servicing: Background, Polling, Sporadic, Slack Stealing, Total Bandwidth
- Resource access control protocols: the priority inversion problem, Non-preemptive protocol, Highest Priority protocol, Priority Inheritance protocol, Stack Resource Policy, Schedulability analysis
- Overload management: Quality of Service, the Skip-Over model, the (m,k) firm model, the imprecise computation model, the Deadline Mechanism

Course material

- Maryline Chetto, Real-time Systems Scheduling 1: Fundamentals, Wiley, 2014
- Jane Liu, Real-time systems, Pearson, 2000
- M. Spuri, G.C. Buttazzo, “Scheduling aperiodic tasks in dynamic priority systems,” Journal of Real-Time Systems, 10(2): 179-210, 1996
- G. Koren, D. Shasha. “Skip-over algorithms and complexity for overloaded systems that allow skips,” 16th IEEE Real-Time Systems Symposium, 1995.
- C.-L. Liu, J.-W. Layland, “Scheduling algorithms for multiprogramming in a hard real-time environment,” Journal of the Association for Computing Machinery, 20(1): 46-61, 1973.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	20 hrs	6 hrs	4 hrs	0 hrs	2 hrs

Cultural and Communication English [CCE3]

LEAD PROFESSOR(S): Spencer HAWKRIDGE

Objectives

Team-building and Communicational English:
- Understand the general concepts of team-building
- Build a team-building project
- Understand and nurture the creative process
- Enhance self-belief and self-empowerment

Behavioral skills in an inter-cultural environment:
- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication
Field-related or inter-cultural project (for example, construct content for inter-cultural teambuilding activities; example WIOBOX website etc).

Course material

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).

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Spanish Language [ESP3]

LEAD PROFESSOR(S): Marta HERRERA

Objectives

For beginners:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of vocabulary and linguistic structures
Be able to talk about yourself and those around you
Be able to express oneself during daily activities
Know how to give your opinion

For advanced students:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of specialised vocabulary
Be able to understand the essential content of concrete or abstract subjects including a technical discussion
Be able to communicate spontaneously and fluently
Be able to express oneself in a clear and detailed manner, to express an opinion on a topical subject

Course contents

For beginners:
Personal environment (introduce yourself, express yourself, your tastes, your character, your hobbies, etc.), your surroundings (friends, family, location, climate), your interests (sports, leisure)
Present tense (regular and irregular)
Language patterns to express habit, obligation, "gustar" and its equivalents,
Possessive adjectives
Differences between "es", "está", "hay"
Use of "por" and "para"
Adverbs and frequency patterns
Numeral adjectives

For advanced students:
Knowledge of the Hispanic world (economic, technical, cultural and social environment)
Present tense (regular and irregular)
Imperative
Past tenses
Direct / indirect style
Future tense
Conditional tense
Present and past subjunctive moods

Course material

Preparation manuals, our own tailor-made documents, written and internet press, general civilization documents, digital tools

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

French Language [FLE3]

LEAD PROFESSOR(S): Silvia ERTL

Objectives

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, 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. Those who already completed the first year of the French course will be prepared for working in a French business environment.

Course contents

Two different tracks are proposed: track 1 for students newly arrived at Centrale Nantes and track 2 for students who have completed the first year of the French course. Track 1:
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

Track 2:
This track follows on directly from the first-year French course, developing and completing the concepts studied thus far. The main themes are: housing, health and work. These topics will help prepare students for their future work environment. For example, housing is explored in the form of a search for accommodation upon arrival in a new city. Special workshops for CVs and cover letters, elevator pitches and job interviews.

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).

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Internship / Thesis project [THESIS]

LEAD PROFESSOR(S): Didier LIME

Objectives

- Be exposed to and adapt to an industrial or research environment
- Put in practice the scientific and technical skills acquired in the previous semesters
- Strengthen interpersonal and communication skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

Course contents

Students should be pro-active and career-oriented in the search for their thesis/internship. The topics are validated by the program supervisor to ensure an adequate Master level. The thesis/internship is evaluated through the submission of a written report and an oral defense.

Course material

- Turabian Kate Larimore, Booth Wayne Clayton, Colomb Gregory G., Williams Joseph M., & University of Chicago press. (2013). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (8th edition.). Chicago (Ill.) London: University of Chicago Press.
- Bui Yvonne N. How to Write a Master's Thesis. 2nd ed. Thousand Oaks, Calif: Sage, 2014.
- Evans David G., Gruba Paul, et Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	30	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs