CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2022-2023

YEAR 1

CONTROL AND ROBOTICS

JAPAN EUROPEAN MASTER ON ADVANCED ROBOTICS - JEMARO

PROGRAMME SUPERVISOR(S):

Vincent FREMONT

YEAR 1 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
ARPRO	Advanced and Robot Programming	4
ARTIN	Artificial Intelligence	4
CLACO	Classical Linear Control	4
DESRO	Mechanical Design Methods in Robotics	4
MANIP	Modelling of Manipulators	4
RTRACK	Research Track1	4
SIPRO	Signal Processing	4

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE1	Cultural and Communication English	2
ESP1	Spanish Language	2
FLE1	French Language	2

YEAR 1 - Spring Semester

CORE COURSES

Course code	Title	ECTS Credits
AIRO	Artificial Intelligence for Robotics	4
COVIS	Computer Vision	4
DYBAC	Dynamic Model Based Control	4
MOBRO	Mobile Robots	4
OPTEC	Optimization Techniques	3
PROJECT	Group Project	6
SOFAR	Software Architecture for Robotics	3

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE2	Cultural and Communication English	2
ESP2	Spanish Language	2
FLE2	French Language	2

Advanced and Robot Programming [ARPRO]

LEAD PROFESSOR(S): Gaëtan GARCIA / Olivier KERMORGANT

Objectives

To provide students with the fundamentals of modern programming (with C++) and industrial robot manipulator programming with specialized robot languages.

After completing the course, students will be able to:

- Write a C++ program from scratch or expand an existing project, using external libraries
- Create their own classes and know how to understand a class interface documentation
- Use tools such as Cmake, Qt Creator, a debugger and a profiler
- Use the STL when needed

In robot programming, the students will be able to:

- Analyze moderately complex robot tasks
- Implement the corresponding robot programs
- Handle robotic tasks involving software interrupts and multiple programs.

Course contents

C++
- Basic types, STL useful classes (string, vector, pair, map), struct
- Control blocks: if/then/else, for, while, switch
- Functions: argument passing, overloading
- Classes: attributes and methods, inheritance
- Templates, lambda-functions and STL algorithms
- Code organization
- Compilation with Cmake, using external libraries
- Debugger and profiler

Industrial manipulator programming
- The different levels of programming,
- Tools for teaching locations,
- Robots, sensors and flexibility,
- Synchronous vs asynchronous motions, guarded motions,
- Tool-level programming,
- Real-time aspects of robot programming,
- The V+ language, including its real-time aspects and sensor-handling capabilities.

Practical Work: C++ labs are essentially oriented towards developing small to large games and problem-solvers. A number of the exercises will not be covered during the labs but solutions will be given.

As for industrial robot programming, the students will be able to practice with a setup of two Stäubli industrial robots, a Puma 560 and a RX 90 programmable in V+. The robots are equipped with a belt conveyor, and a number of sensors.

Course material

- C. Blume, W. Jakob, Programming Languages for Industrial Robots, Springer Verlag.
- Stäubli: RX Robots Technical Documentation, 2001.
- Bruce Eckel, Thinking in C++, volumes 1 and 2, 2007.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	8 hrs	0 hrs	22 hrs	0 hrs	2 hrs

Artificial Intelligence [ARTIN]

LEAD PROFESSOR(S): Diana MATEUS LAMUS

Objectives

This course introduces the key notions of artificial intelligence and machine learning, essential today in dealing with the ubiquitous collection of increasing amounts of data. Starting from general theoretical concepts, we will review the most influential methods for unsupervised and supervised learning, and link them to applications. The sessions will alternate between lectures and practical exercises in Python. Although the techniques will be presented from a broad and general perspective, the applications will focus on image and signal processing

Course contents

- General concepts of machine learning
- Unsupervised methods for clustering and dimensionality reduction
- From linear classification to Support Vector Machines (SVM)
- Decision trees and ensemble methods
- Neural networks and introduction to deep learning
- Evaluation measurements

Course material

[1] Bishop C. : Pattern Recognition and Machine Learning. Springer, 2006.
[2] Kevin Patrick Murphy. Probabilistic Machine Learning: An Introduction. 2022

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

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

Classical Linear Control [CLACO]

LEAD PROFESSOR(S): Guy LEBRET

Objectives

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

- 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:
- Analysis of 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

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.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	22 hrs	4 hrs	4 hrs	0 hrs	2 hrs

Mechanical Design Methods in Robotics [DESRO]

LEAD PROFESSOR(S): Stéphane CARO

Objectives

This course presents an overview of the robot design process: (i) specifications, (ii) conceptual design, (iii) embodiment design and (iv) detailed design. Particular attention will be paid to the conceptual design phase as it is a distinct phase of the design process and 75% of total product life-cycle cost is committed at that stage. The conceptual design deals with the type-synthesis and evaluation of robot architecture. A focus will be placed on the design of serial and parallel robots.

Course contents

Design is an engineering activity that affects almost all areas of human life, using the laws and insights of science, building upon special experience, and providing the prerequisite for the physical realisation of solution ideas.
This course will deal with all the phases of the design process of a product, namely: task definition, conceptual design, embodiment, detailed design.
Particular attention will be paid to the conceptual design phase as stated above.

The following subjects will be discussed:
- Conceptual design: concept generation, concept evaluation.
- Product design: documentation, product generation, evaluation for function and performance, evaluation for cost, ease of assembly and other measures.
- Computer aided design, use of CAD software.
- The design of robotic production cells.
- Fundamentals of integrated design of control and drive systems taking into account measurement, gearing and transmission systems.

After completing this course, the students will be able to:
- Design serial and parallel robotic manipulators.
- Correctly formulate the information required for conceptual design (requirements),
- Use CAD systems on the basic level for the design of a typical mechanism (serial arm),
- Elaborate the design on general level without consideration of material, drive systems and actuators,
- Generate manufacturing drawings.

The course is evaluated with a final exam and a final project that is conducted by groups of two students.
Projects are suggested by the instructor.

Course material

- French, M. J. Conceptual Design for Engineers, 3rd ed., 1999 (Springer)
- Pahl, G. and Beitz, W. Engineering Design: A Systematic Approach, 2nd ed. Wallace, K.M. (editor); Blessing, L., Bauert, F. and Wallace, K.M. (translators), 1996 (Springer-Verlag, London)
- Suh, N.P. The Principles of Design, 1990 (Oxford University Press, Oxford)
- Suh, N.P. Axiomatic Design. Advances and Applications, 2001 (Oxford University Press, Oxford)
- Kong X. and Gosselin, C., Type Synthesis of Parallel Mechanisms, Springer Tracts in Advanced Robotics, 2007.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

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

Modelling of Manipulators [MANIP]

LEAD PROFESSOR(S): Olivier KERMORGANT

Objectives

This course introduces the modelling and basic control of serial robot arms. The topics include robot architecture and modeling conventions, forward and inverse kinematic model, differential kinematic modelling and the basics of trajectory planning and tracking.

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

- Have a clear view of 3D geometry, including rotation parametrization and velocity screws
- Define a table of modified Denavit-Hartenberg parameters to model a robot from a sketch
- Compute (manually or with software) the direct and differential kinematic models
- Derive the inverse kinematic model for standard manipulators (6R / 3P3R)
- Understand position and velocity control modes
- Know how to generate a trajectory from a sequence of 3D waypoints
- Know various symbolic or numeric software tools that can be used to model and control robots

Course contents

- Robot architecture, joint and operational spaces
- Homogeneous transformation matrices, 3D geometry, velocity screw
- Modified Denavit-Hartenberg parametrization and direct kinematics
- Definition and computation of the robot Jacobian
- Inverse kinematics in exact and iterative forms
- Trajectory generation
- Basic position and velocity control modes (trajectory / velocity tracking)

Exercises will involve modelling and simulating various serial manipulators.

Course material

- Slides and labs are available online.
- W. Khalil, and E. Dombre, Modeling, identification and control of robots, Hermes Penton, 2002.

Further reading:

- C. Canudas, B. Siciliano, G. Bastin (editors), Theory of Robot Control, Springer-Verlag, 1996
- J. Angeles, Fundamentals of Robotic Mechanical Systems, Springer-Verlag, New York, 2002.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	0 hrs	14 hrs	0 hrs	2 hrs

Research Track1 [RTRACK]

LEAD PROFESSOR(S): Vincent FREMONT

Objectives

This module allows JEMARO students to work in autonomy on their research topic from the first semester onwards. The aim is to produce a report in which the student develops his/her choice of research subject on which he/she will work until the end of his/her Master's degree, and proposes a first bibliographical study related to the chosen subject. The student will be in close interaction with his/her supervisors (at ECN et Keio University) for the different possible research orientations in relation to the chosen topic.

Course contents

- Exchanges with co-supervisors about the contours of the research subject
- Bibliographical study
- Synthesis report writing
- Oral defense

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Signal Processing [SIPRO]

LEAD PROFESSOR(S): Eric LE CARPENTIER

Objectives

- 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

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

Course material

- 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

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	0 hrs	14 hrs	0 hrs	2 hrs

Cultural and Communication English [CCE1]

LEAD PROFESSOR(S): David TROYA

Objectives

This course aims at improving your critical thinking and persuasion skills in English. Using documentaries, we will explore, discuss and debate a range of cultural, political, social, and environmental issues relevant to current world events.

Speaking and understanding English as a second or third language is a great achievement, but does it mean you are an effective communicator? The next step involves, among other things, critical thinking and persuasive skills, both of crucial importance in the modern professional environment. We will address these issues by analyzing documentaries that will lead to formal debates.

Several competencies will be developed through class exercises. Oral presentations will be an opportunity put your verbal as well as your non-verbal communication skills into practice. During debate, you will be able to sharpen your analytical skills, provide constructive feedback, defend an argument, and prove a point.

Course objectives

- Improving your communication skills

- Becoming an active listener

- Enhancing your non-verbal communication skills

- Developing critical thinking toward media

- Boosting leadership skills through moderating

- Organizing evidence and arguments

Course contents

Each session will be dedicated to a particular cultural, political, social or environmental topic of relevance in the wider anglophone world. Each topic will include multimedia material in the form of a short documentary or documentary excerpt. During class, students will lead a primer presentation, a moderated discussion and a formal debate.

Primer Presentation:

In pairs, you will hold a short talk to prime us on the topic of that week's documentary: you will introduce us to the topic by setting it in a wider context and establishing what's at stake.

Moderated Discussion :

In pairs, you will moderate a discussion related to the themes explored by the documentary. Moderators will come prepared with open-ended questions pertaining to the strengths and weakness of the documentary. They will distinguish between content and form and encourage critical, constructive opinions.

Formal Debate:

What's the difference between an opinion and an argument? You will soon find out. After the moderated discussion, we will

brainstorm potential topics for debate, and follow the British Parliamentary model to sharpen your research, critical thinking, and persuasive skills.

During the debate, each speaker will be assigned an audience member who evaluates their individual performance and provides a short debrief. A panel of two judges will determine which side wins.

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	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Spanish Language [ESP1]

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	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

French Language [FLE1]

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 (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

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. Gving 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

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	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Artificial Intelligence for Robotics [AIRO]

LEAD PROFESSOR(S): Vincent FREMONT

Objectives

This course aims to present recent artificial intelligence techniques for robotics.

Course contents

Lectures:

- Applied Math and optimization technics for Machine Learning
- Convolutional Networks
- Semantic Segmentation
- Object Detection
- Place recognition for SLAM
- Belief Functions Theory: application to Evidential Occupancy Grids for autonomous vehicles
- Hardware and GPU processing for Deep Learning
- Deep Learning Frameworks

Practical Sessions:

Lab1: Object detection using Deep Learning
Lab2: Reinforcement Learning
Lab3: Deep Reinforcement Learning

Course material

- Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville.
- Artificial Intelligence for Robotics: Build intelligent robots that perform human tasks using AI techniques, Francis X. Govers, 2018.
- Course by Andrea Vedaldi: http://www.robots.ox.ac.uk/~vedaldi/teach.html
- Ethics of Artificial Intelligence and Robotics: https://plato.stanford.edu/entries/ethics-ai/

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Computer Vision [COVIS]

LEAD PROFESSOR(S): Vincent FREMONT

Objectives

▪ To acquire knowledge and skills in computer vision and image processing to understand and to master methods for artificial perception and scene understanding.
▪ To learn to implement current visual odometry pipelines used in mobile robots and to understand and how to tune Deep Learning algorithms for semantic segmentation.

Course contents

▪ Introduction
▪ Image Formation 1: perspective projection and camera models
▪ Image Formation 2: camera calibration algorithms
▪ Filtering and Edge detection
▪ Feature Point Detection
▪ Multiple-view Geometry and Robust Estimation
▪ Optical Flow and Feature Tracking
▪ Visual SLAM Frameworks
▪ Deep Learning and Semantic Segmentation

Practical Work: Sessions on camera calibration, template tracking and object detection will be proposed.

Course material

Recommended textbooks:

▪ Digital Image Processing, by Rafael C. Gonzalez and Richard E. Woods, 2018
▪ Computer Vision: Algorithms and Applications, by Richard Szeliski, 2009.
▪ Multiple view Geometry, by R. Hartley and A. Zisserman, 2003.
▪ An Invitation to 3D Vision, by Y. Ma, S. Soatto, J. Kosecka, S.S. Sastry, 2004.
▪ Robotics, Vision and Control: Fundamental Algorithms, by Peter Corke, 2011.

Online courses:

▪ Course by Davide Scaramuzza: http://rpg.ifi.uzh.ch/teaching.html
▪ Course by James Hays at Brown University: https://www.cc.gatech.edu/~hays/
▪ Course by Andrea Vedaldi: http://www.robots.ox.ac.uk/~vedaldi/teach.html

Further reading: will be provided by lecturer

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

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

Dynamic Model Based Control [DYBAC]

LEAD PROFESSOR(S): Guy LEBRET / Sébastien BRIOT

Objectives

To show that using in a control law "a dynamic model" of a dynamical system can be the base of a fruitful control methodology. This course is an extension of two courses: Classical Linear Control and Modelling of Manipulators.
In the first part (16h), for linear multivariable systems, the model is used, first of all, to obtain observer-based controllers (state space approach of linear multivariable systems) as the feedback part of the control law, and secondly, in a possible feedforward part.
In the second part (16h), it is shown how the dynamic model of mechanisms or, more specifically, serial robots can be obtained, as this model is the basis of the so-called "computed torque control law". Different formalisms for the computation of the dynamic model will be explored (Newton-Euler, Lagrange equations).

Clearly, the objective of the course is to present a unified methodology to obtain control laws. In this methodology, once the dynamic model has been obtained, then the non-linear coupled MIMO systems can be linearized and decoupled, and finally the linear methodology of the first part can be applied.

Course contents

Part 1 state space approach of linear multivariable systems:
- Time domain state response, modal decomposition of the response
- Controllability, observability
- Observer-based controllers
- Possible two degrees of freedom controllers.

Part 2, mechanisms or more specifically, serial robots:
- Recalls of classical mechanics
- Newton-Euler equations
- Euler-Lagrange equations
- Optimal computation of dynamic models for serial robots (recursive formalisms)

Skills: After completing this course the students will be able to
- Use all classical tools of the linear state space approach to analyse (mode, controllability, etc) and design observer-based controllers.
- Compute the dynamic model of open-loop mechanisms and robots
- Evaluate the benefit of the use of a dynamical model in a control law.

Course material

Recommended texts: Course notes will be provided by the lecturers.

Further reading:

- "Control system design", G.C. Goodwin, S.F. Graebe and M.E. Salgado, Prentice Hall, 2001.
- "Linear Multivariable Control, A Geometric Approach", W.M.Wonham. Springer Verlag, New York, 1985.
- "Linear Systems", T. Kailath, Prentice-Hall, New Jersey, 1980.
- "Modelling, Identification and Control of Robots" W. Khalil and E. Dombre, Hermes Penton, Ltd, 2002

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	22 hrs	4 hrs	4 hrs	0 hrs	2 hrs

Mobile Robots [MOBRO]

LEAD PROFESSOR(S): Gaëtan GARCIA

Objectives

The objective of the course is to provide students with the necessary tools to model, localize and control conventional wheeled mobile robots, along with tools to plan their path..

Course contents

The following subjects will be addressed:

- Modelling of wheeled Robots: Constraint equations, Classification of robots using degrees of mobility and steerability, Posture kinematic model, Configuration kinematic model, Motorisation of wheels.
- Localization: Relative localization using odometry, Absolute localisation, Localization sensors, Localization using extended Kalman filtering. Observability analysis of localization problems.
- Control: Controllability and stabilization, static and dynamic feedback linearization, non-linear control based on Lyapunov functions.

Practical Work: The students will study various control laws in simulation. They will also implement a Kalman filter-based localization algorithm using data recorded with a real robot.

Course material

- “Theory of robot control”, Carlos Canudas de Wit, Bruno Siciliano, Georges Bastin, Springer Science & Business Media, 2012 - 392 pages.
- "Wheeled Mobile Robots—Kinematic Modelling", G. Garcia, Class material in book form.
- "Mobile robots—Localization", G. Garcia, Class material in book form.
- "Principles of robot motion", H. Choset et. al., Bradford books, MIT Pres.

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Optimization Techniques [OPTEC]

LEAD PROFESSOR(S): Alexandre GOLDSZTEJN / Fouad BENNIS

Objectives

The course presents different theoretical and computational aspects of a wide range of optimization methods for solving a variety of problems in different fields related to the Master's program. The main objective of this course is to give the students the ability to formalise, select the appropriate method, implement the optimisation problem and then analyse the results in order to take the best decision regarding the objectives, variables and constraints. The students will be able to understand different theoretical and computational aspects of a wide range of optimization methods.

Course contents

- Basic concepts of optimization
- The steepest descent method
- Advanced descent methods
- Linear programming
- Multi objective optimization
- Robust optimization methods
- Use of optimization toolboxes

Course material

Jorge Nocedal, Stephen J. Wright: Numerical Optimization, Springer New York, NY.
Dimitri P. Bertsekas: Nonlinear Programming, Athena Scientific.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	3	14 hrs	0 hrs	16 hrs	0 hrs	2 hrs

Group Project [PROJECT]

LEAD PROFESSOR(S): Gaëtan GARCIA

Objectives

To contribute to solving a scientific, technological or theoretical problem proposed by any of the instructors of the master (professors, assistant professors, researchers etc.) or industrial partners.

Course contents

The students (individually or often as a group of two) organize the project. Depending on the subject, a bibliography may be necessary, an original methodology or solution can be proposed or it can involve purely the application of techniques learned throughout the courses.

32 hours are set aside for the project in the timetable, but additional personal work will be required. Project assessment is based on a written report and an oral presentation.

Course material

To be provided by the supervisor(s) if necessary.

Assessment

Collective assessment: EVC 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	6	0 hrs	0 hrs	0 hrs	32 hrs	0 hrs

Software Architecture for Robotics [SOFAR]

LEAD PROFESSOR(S): Gaëtan GARCIA

Objectives

The main objective of Software Architecture for Robotics is to provide students with methodological tools and practical information about how to design and develop complex software architecture for intelligent robots. Nowadays, robots can be considered as complex systems made up of modules and components whose behavior is complex in its own right. Given a specific scenario where a robot must operate autonomously and effectively, the problem of defining software architecture requires one to:

- define which sensory information is needed and how it must be processed;
- couple sensory information and internal representation structures, which must be appropriate in terms of efficiency, computational load and usability;
- design and develop algorithms to operate on such representation structures;
- embed those algorithms in software modules and components, which must be concurrently executed on (typically realtime) operating systems.

The course provides a principled treatment of current stateoftheart design approaches, development frameworks, modelling tools and advanced research trends in this field, as well as a comprehensive discussion about typical scenarios, solutions and use cases. In terms of development framework, the objective is to obtain sufficient command of ROS (Robot Operating System – web: http://www.ros.org/) to implement moderately complex applications.

Course contents

The course covers the following aspects:

- Design patterns for robot software development,
- Component-based software engineering aspects,
- Typologies of software architecture for robots, and their use in real-world scenarios,
- Biologically-inspired approaches to robot software design,
- Real-time and non-real-time software components,
- Integration of robot perception, knowledge representation, reasoning, and action.
- Practical introduction to ROS in the labs.

Course material

Relevant material will be provided by the instructors during the course

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	3	12 hrs	0 hrs	18 hrs	0 hrs	2 hrs

Cultural and Communication English [CCE2]

LEAD PROFESSOR(S): David TROYA

Objectives

Interview techniques and communicational English:

- Understand the general concepts of interactive communication
- Build a media project
- Acquire interview techniques
- Understand the process of sourcing and checking facts and figures
- Understand issues related to plagiarism
- Create a bibliography
- 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.
Media project (for example: prepare, conduct and promote interviews for a radio programme: L'Heure Centralienne (http: //www.euradionantes.eu/emission/l-heure-centralienne), with the contribution of professors, PhD students, industrial partners, industry players at fairs, 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	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

Spanish Language [ESP2]

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	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

French Language [FLE2]

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 (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

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

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	2	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs