SHAKE THE FUTURE.

CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

CONTROL AND ROBOTICS

SIGNAL AND IMAGE PROCESSING

YEAR 1
SPRING SEMESTER

PROGRAMME SUPERVISORS:
GUY LEBRET, OLIVIER-HENRI ROUX

Établissement public sous tutelle du ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

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PROJECT

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

LEAD PROFESSOR: Guy Lebret, *guy.lebret@ec-nantes.fr*

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 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

Keywords

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

OPTIMIZATION TECHNIQUES

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

LEAD PROFESSOR: Fouad Bennis, *fouad.bennis@ec-nantes.fr*

Objectives

The lecture presents different theoretical and computational aspects of a wide range of optimization methods for solving a variety of problems in mechanical engineering. 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.

Course contents

- Basic concepts of optimization,
- Gradient based methods,
- Evolutionary algorithms,
- Multi objective optimization methods,
- Robust optimization methods,
- Multidisciplinary optimization problems,
- Programming aspects,
- Use of optimization toolbox.

Practical Work: exercises and a project on the design optimisation of a mechanical product, manufacturing process or system.

The students will be able to understand different theoretical and computational aspects of a wide range of optimization methods.

Course material

R. Fletcher, Practical Methods of Optimization, Wiley, 2000.
Mitchell Melanie: An Introduction to Genetic Algorithms, MIT Press 1996

Keywords

Optimisation, gradient based approach, population-based approach, trajectory-based approach

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

MOBILE ROBOTS

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

LEAD PROFESSOR: Gaëtan Garcia, *gaetan.garcia@ec-nantes.fr*

Objectives

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

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.
- 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.
- PDF documents provided by the teachers.

Keywords

Mobile robots, modelling, localization, control.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	20 hrs	0 hrs	12 hrs	0 hrs	2 hrs

PROGRAMMING REAL TIME SYSTEMS

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

LEAD PROFESSOR: Sébastien Faucou, *sebastien.faucou@univ-nantes.fr*

Objectives

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

- Design the software architecture of a real-time system
- Build deterministic programmes with a multitasking RTOS
- Handle time and recurring events in a real-time application
- Understand and solve race conditions in concurrent software

Course contents

- Introduction to real time systems: what is a real time system, classes of timing constraints, basic model and results on real time scheduling
- Trampoline RTOS: what is a RTOS, when is it useful, architecture of Trampoline, build process, task management and scheduling, synchronisation, handling of recurring events, shared resources
- Design of real time applications: case studies and design patterns

Course material

- Alan Burns, Andy Wellings, Analysable Real-Time Systems: Programmed in Ada, CreateSpace Independent Publishing Platform, 2016
- Giorgio C. Buttazzo, Hard Real-Time Computing Systems: Predictable Scheduling Algorithms and Applications, Springer, 2011
- Philip Koopman, Better Embedded Software Systems, Drumnadrochit Education LLC, 2010

Keywords

Real-time system, RTOS, application design

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

COMPUTER VISION

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

LEAD PROFESSOR: Vincent Fremont, *vincent.fremont@ec-nantes.fr*

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 low-level image processing, Structure-from-Motion and Semantic Segmentation 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

Keywords

Image Processing, Feature detection and Tracking, Multiple-view Geometry, Visual SLAM, Deep Learning for Semantic Segmentation.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	20 hrs	0 hrs	12 hrs	0 hrs	2 hrs

SPECTRAL AND TIME FREQUENCY ANALYSIS

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

LEAD PROFESSOR: Sébastien Bourguignon, *sebastien.bourguignon@ec-nantes.fr*

Objectives

Spectral analysis concerns the estimation of the frequency content of a given signal, which is the fundamental tool for detecting and characterizing harmonic components or wideband phenomena in stationary signals. This course first provides an overview of most frequently used spectral analysis tools, from standard methods based on Fourier analysis to high-resolution methods. Next, time-frequency analysis is considered, which extends spectral analysis to non-stationary signals (that is, when the frequency content changes with time).
The different spectral analysis and time-frequency methods are presented, both in their mathematical and informational foundations and in their practical numerical implementation, through application examples taken from real and simulated data analysis problems.

Course contents

- Fourier-Transform-based spectral analysis methods of discrete-time stationary signals. Power and limitations, windowing, periodograms.
- High-resolution methods of discrete-time stationary signals: linear prediction models, subspace methods, regularized methods.
- Generalization to spectral analysis of images or higher-dimensional data.
- Labs/projects: detection of multiple oscillating components in noise; exoplanet detection from time series; Fourier-based image compression.
- Linear time-frequency representations based on the Short-Term Fourier Transform
- Quadratic time-frequency representations: Wigner-Ville distributions, Cohen's class.
- Labs/projects: comparison of different time-frequency representations; application to automatic transcription of a musical score; use of time-frequency representations for automatic classification (speaker recognition).

Course material

- A.V. Oppenheim and R.W. Schafer. Discrete-time signal processing, Prentice Hall, 2010.
- P. Stoica and R. Moses. Spectral Analysis of Signals, TBS, 2005.
- S. Kay. Modern Spectral Estimation, Prentice -Hall, Englewood Cliffs, 1988.
- L. Cohen, Time-Frequency analysis, Prentice-Hall, 1995.

Keywords

Spectral analysis, Fourier transform, time series, non-stationary signals, time-frequency analysis.

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

MODERN LANGUAGES - FRENCH

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

LEAD PROFESSOR: Silvia Ertl – *silvia.ertl@ec-nantes.fr*

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

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

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 - SPRING SEMESTER

LEAD PROFESSOR: Spencer Hawkridge- *spencer.hawkridge@ec-nantes.fr*

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).
Our own eZoomBook template for the Intercultural project.

Keywords

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