Erasmus Mundus Joint Master in
INTELLIGENT FIELD ROBOTIC SYSTEMS

IFRoS

Erasmus+

Course description

Universitat de Girona

COURSE MODULES

1st SEMESTER (30 ECTS at UDG)

Robot Manipulation	6 ECTS
Probabilistic Robotics	6 ECTS
Autonomous Systems	6 ECTS
Multiview Geometry	6 ECTS
Machine Learning	6 ECTS

2nd SEMESTER (30 ECTS at UDG)

Hands-on Intervention	6 ECTS
Hands-on Localization	6 ECTS
Hands-on Perception	6 ECTS
Hands-on Planning	6 ECTS
Management	3 ECTS
Research best practices	3 ECTS
Total ECTS	**60 ECTS**

3rd SEMESTER

30 ECTS at UNIZG

Multi-robots systems	5 ECTS + 1 ECTS seminar
Human-robot interaction	5 ECTS
Ethics and technology	2 ECTS
Aerial Robotics	5 ECTS
Robotic Sensing, Perception, and Actuation	5 ECTS + 1 ECTS seminar
Machine learning	5 ECTS + 1 ECTS seminar

30 ECTS at ELTE

Advanced Machine Learning	6 ECTS
Introduction to vehicles and Sensors	4 ECTS
3D Sensing and Sensor Fusion	6 ECTS
Intelligent Field Robots lab	6 ECTS
Methods and tools for AI Applications	6 ECTS
Preparation course for master studies and developing learning skills	2 ECTS
Total ECTS	**30 ECTS**

4th SEMESTER (30 ECTS at any HEI or associated partner)	
Master thesis	**30 ECTS**

COURSE MODULES 1st semester

M1.1 Robot Manipulation

Main Topics	Manipulator Kinematics and dynamics, trajectory control, force-based control
ECTS	6
University	UdG
Course contents	1. Introduction to industrial manipulators 2. Forward & Inverse Kinematics 3. Diferential Kinematics 4. Dynamics 5. Motion Control
Outcomes	Student have a detailed view of the theory and programming of industrial manipulators and understand manipulator kinematics and dynamics as well as the basics about path genaration and control.

M1.2 Probabilistic Robotics

Main Topics	Montecarlo and Gaussian based algorithms
ECTS	6
University	UdG
Course contents	1. Introduction 2. Bayes Filter 3. Non Parametric Filters 4. Parametric Filters 5. Map-based Localization 6. Feature-based SLAM
Outcomes	Student know how to localize an autonomous mobile robots using noisy sensors, how to to map the surroundings of a robot, how to use a map to localize a robot and how to localize a robot while mapping its environment.

M1.3 Autonomous Systems

Main Topics	Mobile Robots, Path and task planning
ECTS	6
University	UdG
Course contents	1. Autonomous robots 2. Reactive control 3. Motion planning 4. Task Planning 5. Introduction to Exploration
Outcomes	Student has the fundamental concepts required to work with autonomous mobile robots: software architectures, robot motion, path planning, task planning. Student is able to develop applications using the Robot Opeartive System as well as to know some of the main libraries related to robotics.

M1.4 Multiview Geometry

Main Topics	Image processing, calibration, multicamera vision.
ECTS	6
University	UdG
Course contents	1. Basic concepts of computer vision 2. Image formation and camera modelling 3. Camera Calibration 4. Feature detectors and descriptors 5. Robust estimation in computer vision 6. Geometry of multiple camera views 7. Structure-from-Motion and optimization pipelines 8. Real-time computer vision and Vision applied to Robotic systems 9. Non-conventional optical imaging systems
Outcomes	Student has a comprehensive knowledge of the theoretical and practical aspects of computing with multiple images.

M1.5 Machine Learning

Main Topics	Machine learning algorithms.
ECTS	6
University	UdG
Course contents	1. Linear Algebra Review 2. Linear Regression with One Variable 3. Linear Regression with Multiple Variables 4. Logistic Regression 5. Decision Trees 6. Naive Bayes 7. Neural Networks 8. Support Vector Machines 9. Ensemble Methods
Outcomes	Student understand and has a comprehensive knowledge on the building blocks of machine learning algorithms.

COURSE MODULES 2nd semester

M2.1 Hands-on Intervention

Main Topics	Visual servoing and task priority intervention project
ECTS	6
University	UdG
Course contents	1. Visual servoing 2. Force control 3. Task priority control 4. Hands-on project
Outcomes	Student is able to implement a visual servoing and a task priority method and is capable to understand state-of-the-art literature about autonomous manipulation.

M2.2 Hands-on Localization

Main Topics	Robot localization project using SLAM
ECTS	6
University	UdG
Course contents	1. SLAM using the particle filter 2. Reviewing and discussing the most relevant articles in the field 3. SLAM using the Extended Kalman flter 4. Reviewing and discussing the most relevant articles in the field 5. Hands-on project
Outcomes	Student is capable to implement SLAM algorithms based on particle and Kalman filters to solve location and mapping problems in mobile robots.

M2.3 Hands-on Perception

Main Topics	Advanced perception project
ECTS	6
University	UdG
Course contents	Review of most used approaches for: 1. Multicamera Calibration and metrology 2. Map based Pose Estimation 3. 2D optical mapping 4. Hands-on project
Outcomes	Student has the practical knowledge on fundamental components of visual perception for mobile robots, namely on multicamera calibration, visual SLAM and optical mapping of the environment.

M2.4 Hands-on Planning

Main Topics	Project on advanced path planning and exploration
ECTS	6
University	UdG
Course contents	1. Search-based motion planning algortihms 2. Sample-based motion planning algortihms and informed sampling 3. Information driven exploration 4. Hands-on project
Outcomes	Student has an up-to-date knowledge of search and sampling-based planning algorithms and is able to implement an autonomous exploration algorithm adapted to a field robot.

M2.5 Management

Main Topics	Project Management & Entrepreneurship skills
ECTS	3
University	UdG
Course contents	1. Management, communication & leadership 2. From the idea to the market 3. Business plan 4. Case studies 5. Teamwork project
Outcomes	Student has a comprehensive knowledge about how to communicate, motivate and inspire, as well as how to build and lead teams. Student understand what a business plan is and is able to implement one.

M2.6 Research best practices

Main Topics	Best practices in Research and Scientific Writing
ECTS	3
University	UdG
Course contents	1. Principles of Research Ethics 2. Principles of effective writing 3. Organization and formatting 4. The Publication process 5. Issues in scientific writing 6. Peer reviewing and science dissemination
Outcomes	Student has a comprehensive knowledge about the principles of ethics in research. Student is capable to correctly structure a scientific article and understands the editorial process.

COURSE MODULES 3rd semester

M3.1 Multi-robots systems

Main Topics	The main goal of the course is to acquaint students with the analysis and synthesis of multi-robot systems and to train them in understanding the procedures of analysis and synthesis of multi-robot systems.
ECTS	5 ECTS + 1 ECTS seminar
University	UNIZG
Course contents	1. Coordination 2. Formation control 3. Robot swarms 4. Cooperative task execution in multi-robot systems
Outcomes	Student is able to categorize problems in multi-agent systems and understand their organizational structure, and is able to connect existing ideas from the field of multi-agent systems and is able to offer novel solution

M3.2 Human-robot interaction

Main Topics	The main goal of the course is to teach students the basic principles of human-robot interaction through understanding the principles of multimodal interaction, principles of how to estimate himan intentions, the concept of task sharing and physical interaction.
ECTS	5
University	UNIZG
Course contents	1. HRI concept and interfaces 2. Multimodal interaction 3. Cooperative task execution 4. Physical interaction 5. Teleoperation
Outcomes	Student is capable to define and describe the principles of phyisical interaction between humans and robots and knows basic principles of haptic teleoperation.

M3.3 Ethics and technology

Main Topics	The main goal of this course is to acquint students with major issues related to the ethical questions that arise with development of novel technologies, such as robotics, autonomous systems and artificial intelligence, and to shed light on social and legal consequences of these technologies.
ECTS	2
University	UNIZG
Course contents	1. Basics of Ethics 2. Deontology, Utilitarianism and Ethics of Virtue 3. Ethics of autonomous systems 4. Ethics of medical and social robots 5. Society and artificial intelligence
Outcomes	Student has a basic understanding on ethical issues involved with development of novel technologies, such as robotics, artificial intelligence and autonomous systems

M3.4 Aerial Robotics

Main Topics	The main objective of this course is to enable students to fully understand the design of aerial robots, taking into account electromechanical components, dynamic modeling and control algorithms required for the design of small drones.
ECTS	5
University	UNIZG
Course contents	1. Airframe design 2. Flight dynamics 3. Propulsion systems in aerial robotics 4. Flight control 5. Aerial manipulation
Outcomes	Upon completion of their studies, student is able to develop unmanned aerial vehicle control system, derive a mathematical model of unmanned aerial vehicle dynamics, and, finally, design a controllable rotorcraft capable of applying contact with the environment.

M3.5 Robotic Sensing, Perception, and Actuation

Main Topics	The main goal of the course is to to teach the students about the characteristics of sensors and actuators used in robotics and to acquaint them with implementation of methods for acquiring and processing signals from proprioceptive and perceptual sensors, as well as with basic principles of robotic actuators.
ECTS	5 ECTS + 1 ECTS seminar
University	UNIZG
Course contents	1. Proprieceptive sensors 2. Perceptive sensors 3. Sensor fusion 4. Smart environment 5. Visual servoing 6. Electric motors and servos 7. Pneumatic and hydraulic motors 8. Artificial muscles
Outcomes	Student has a comprehensive knowledge on sensors and actuators in robotics and knows how to design smart environments and how to integrate robots into smart environments

M3.6 Machine learning

Main Topics	The main objective of the course is to acquint students with advanced methods of computer learning theory with application to classification and regression algorithms, as well as to teach students advanced concepts of machine learning: bayesian machine learning, sparse kernel machines, and semi-supervised machine learning.
ECTS	5 ECTS + 1 ECTS seminar
University	UNIZG

Course contents	1. Non-parametric models 2. Kernel methods 3. Classifier evaluation 4. Dimensionality reduction 5. Neural networks 6. Semi-supervised learning 7. Inductive logic programming 8. Ensambles 9. Clustering 10. Deep learning 11. Reinforcement learning
Outcomes	Student has a comprehensive knowledge on methods of computer learning theory with application to classification and regression algorithms, and is able to implement advanced machine learning concepts.

M3.7 Advanced Machine Learning

Main Topics	Advanced machine learning algorithms and tools
ECTS	6
University	ELTE
Course contents	1. Network architectures 2. Image processing 3. Motion and control 4. Anomaly detection 5. Studying, designing, using DNN
Outcomes	Student has a comprehensive knowledge on advanced machine learning methods, including the deep learning approaches.

M3.8 Introduction to vehicles and Sensors

Main Topics	Perception sensors focus on land robotics
ECTS	4
University	ELTE
Course contents	1. Principles of autonomous vehicles, and self-driving cars 2. Hardware and software architectures 3. Sensors, interconnect networks, actuators, processing elements 4. Radars, LIDAR's, cameras, ultrasonic, GPS, and other sensors 5. CAN, LIN, MOST, FlexRay vehicle interconnect networks and architectures 6. Intelligent transportation systems
Outcomes	Student has a comprehensive knowledge on autonomous vehicles and their sensors, including up-to-date knowledge of sensor technology, capabilities, limits of vehicle sensors used in intelligent transportation systems.

M3.9 3D Sensing and Sensor Fusion

Main Topics	Theoretical and practical fundamentals of autonomous car sensors
ECTS	6
University	ELTE
Course contents	1. Operation principles of 3D sensors 2. Active and passive 3D sensing 3. Sensor fusion on data and feature level and in state space 4. Camera LiDAR and camera-depth camera fusion 5. Sensor fusion and semantic segmentation
Outcomes	Student has a comprehensive knowledge on 3D sensing and sensor fusion.

M3.11 Intelligent Field Robots lab

Main Topics	Projects focusing on various aspect of intelligent field robots design and development.
ECTS	6
University	ELTE
Course contents	During the lab, students will work in teams on intelligent field robot tasks on real life problems gathered from industrial as well as academic partners of the Faculty. The tasks will concern both basic and applied research and development under the supervision of experienced scientists.
Outcomes	Student can apply his/her knowledge and understanding, and problem-solving abilities on intelligent field robots, have the ability to integrate knowledge and handle complexity.

M3.12 Methods and tools for AI Applications

Main Topics	AI theoretical and practical toolset
ECTS	6
University	ELTE
Course contents	1. Probabilistic basics and algorithmic methods: - Modelling data, - Likelihood estimations, - Likelihood approximations, - Unsupervised methods 2. AI software languages and formulation of the algorithms: - Basics, - Algorithms in software
Outcomes	Student is able to use and design tools and methods for AI applications.

M3.13 Preparation course for master studies and developing learning skills

Main Topics	Transversal course in learning methodologies
ECTS	2
University	ELTE
Course contents	1. Develop communication and learning skills 2. Learn successfully and efficiently 3. Time management and organization 4. Group versus self study 5. Improving social relationships
Outcomes	Student is able to learn successfully and efficiently, manage time, balance private life and studies, work and learn in groups, improve it's social relationship.

COURSE MODULES 4th semester

M4.1 Master thesis

Main Topics	Master's thesis on intelligent field robotic systems
ECTS	30
University	Any HEI or associated partner
Course contents	Master thesis
Outcomes	Perform a master thesis.


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