# Professional Master's Degree
## Robotics

# Professional Master's Degree
## Robotics

Course: **Online**
Duration: **12 months**
Certificate: **TECH Technological University**
Teaching Hours: **1,500 h.**
Website: **www.techtitute.com/in/engineering/professional-master-degree/master-robotics**

# Index

# 01
# Introduction

The progressive and unstoppable robotization and automation of more and more industries and businesses has made robotics one of the most advanced fields of engineering in recent years. From the viral videos of Boston Dynamics to the most cutting-edge drones, robots are part of the popular ideology and daily life of many people. Engineers who wish to specialize in this field must have a high level of expertise, as projects such as autonomous cars or space exploration require the best professionals in the field. This TECH program gathers the knowledge, precisely, of doctors in engineering and professionals specialized in robotics, with experience in the academic and aerospace fields. A great opportunity to give a decisive boost to your professional career with a 100% online teaching, free of face-to-face classes and preset schedules.

*Become a specialist in Industry 4.0, industrial process automation, robot planning algorithms and much more content created by robotics experts"*

It is undeniable that robotics has driven the advancement of industry to levels that were unimaginable just a few years ago. It is already common to talk about Machine Learning or Artificial Intelligences, fields in which robotics can expand to offer almost futuristic solutions to everyday or even medical problems, with robotic assistants in complex operations.

All this generates an undeniable growth opportunity for professional engineers who dedicate themselves to this field, as they will find a multitude of areas and projects to which they can direct their careers. From the purely industrial field to aerospace technologies and international programs, an appropriate specialization in robotics can mean a quantitative and qualitative leap in quality for the engineers in their own professional career.

For this reason, TECH has assembled for this program a team of leaders in the field of robotics, with extensive experience in numerous international projects of great prestige and an impeccable academic curriculum. Precisely this teaching profile means that the entire content of the program has a unique theoretical-practical approach, where the engineer will not only find the latest developments in robotics, Artificial Intelligence and Communication Systems, but also the practical application of all this knowledge in real working environments.

Through numerous videos in detail, complementary readings, video summaries and self-knowledge exercises, the engineer will obtain a global and specialized vision of the current state of robotics, being able to incorporate to his resume a program that positions him as a valuable asset for any company in the sector. All this, in addition, with the advantage of being able to manage the Professional Master's Degree at your own pace, without having to attend classes or fixed schedules of any kind. The teaching is 100% online and allows the necessary flexibility to combine it with the most demanding personal and professional activity.

This **Professional Master's Degree in Robotics** contains the most complete and up-to-date program on the market. The most important features include:

- Development of case studies presented by experts in robotic engineering
- The graphic, schematic, and practical contents with which they are created, provide scientific and practical information on the disciplines that are essential for professional practice
- Practical exercises where self-assessment can be used to improve learning
- Its special emphasis on innovative methodologies
- Theoretical lessons, questions to the expert, debate forums on controversial topics, and individual reflection assignments
- Content that is accessible from any fixed or portable device with an Internet connection

> *"Join a program in which you will be the one who decides how, where and when to take on the entire course load, without having to sacrifice your personal or professional life to do so"*

*Enroll now and don't miss the opportunity to delve into the application of robotics to virtual and augmented reality technologies, with virtual sensors and mixed mobile applications"*

*Get the boost your career needs by incorporating this Professional Master's Degree in your value proposal.*

*Master the most advanced and modern Robotics with topics dedicated exclusively to visual SLAM, computer vision and Visual Servoing.*

The program's teaching staff includes professionals from the sector who contribute their work experience to this training program, as well as renowned specialists from leading societies and prestigious universities.

Its multimedia content, developed with the latest educational technology, will provide the professional with situated and contextual learning, i.e., a simulated environment that will provide an immersive education programmed to learn in real situations.

The design of this program focuses on Problem-Based Learning, by means of which the professionals must try to solve the different professional practice situations that are presented throughout the program. For this purpose, the student will be assisted by an innovative interactive video system created by renowned experts.

02

# Objectives

The objective of this program could not be other than to offer the engineer the most rigorous and current contents in Robotics. Therefore, throughout the 10 extensive modules of knowledge that make up this Professional Master's Degree, there will be many references to real robotics cases. This casuistry has been created by the teaching team itself, so that the engineer can incorporate the knowledge of the subject to their daily work in the most practical and quickest way possible.


*Thanks to TECH's advanced teaching methodology, you will save many hours of study time, which you can invest in the large library of multimedia content created specifically for this program"*

## General Objectives

- Understand the mathematical foundations for kinematic and dynamic modeling of robots
- Delve into the use of specific technologies for the creation of robot architectures, robot modeling and simulation
- Generate specialized knowledge on Artificial Intelligence
- Develop the technologies and devices most commonly used in industrial automation
- Identify the limits of current techniques to identify bottlenecks in robotic applications

*You will have the full support of TECH's technical and teaching team to help you achieve your most ambitious professional goals"*

## Specific Objectives

### Module 1. Robotics: Robot Design and Modeling

- Delve into the use of Gazebo Simulation Technology
- Master the use of the URDF Robot Modeling language
- Develop specialized knowledge in the use of Robot Operating System technology
- Model and simulate manipulator robots, land mobile robots, air mobile robots and model and simulate aquatic mobile robots

### Module 2. Intelligent Agents. Applying Artificial Intelligence to Robots and Softbots

- Analyze the biological inspiration of Artificial Intelligence and intelligent agents
- Assess the need for intelligent algorithms in today's society
- Determine the applications of advanced Artificial Intelligence techniques on Intelligent Agents
- Demonstrate the strong connection between Robotics and Artificial Intelligence
- Establish the needs and challenges presented by Robotics that can be solved with Intelligent Algorithms
- Develop concrete implementations of Artificial Intelligence Algorithms
- Identify Artificial Intelligence algorithms that are established in today's society and their impact on daily life

### Module 3. Robotics in the Automation of Industrial Processes

- Analyze the use, applications and limitations of industrial communication networks
- Establish machine safety standards for correct design
- Develop clean and efficient programming techniques in PLCs
- Propose new ways of organizing operations using state machines
- Demonstrate the implementation of control paradigms in real PLC applications
- Fundamentalize the design of pneumatic and hydraulic installations in automation
- Identify the main sensors and actuators in robotics and automation

### Module 4. Automatic Control Systems in Robotics

- Generate specialized knowledge for the design of nonlinear controllers
- Analyze and study control problems
- Master control models
- Design nonlinear controllers for robotic systems
- Implement controllers and assess them in a simulator
- Determine the different existing control architectures
- Examine the fundamentals of vision control
- Develop state-of-the-art control techniques such as predictive control or machine learning based control

### Module 5. Robot Planning Algorithms
- Establish the different types of planning algorithms
- Analyze the complexity of motion planning in robotics
- Develop techniques for environment modeling
- Examine the pros and cons of different planning techniques
- Analyze centralized and distributed algorithms for robot coordination
- Identify the different elements in decision theory
- Propose learning algorithms for solving decision problems

### Module 6. Artificial Vision Techniques in Robotics: Image Processing and Analysis
- Analyze and understand the importance of vision systems in robotics
- Establish the characteristics of the different perception sensors in order to choose the most appropriate ones according to the application
- Determine the techniques for extracting information from sensor data
- Apply visual information processing tools
- Design digital image processing algorithms
- Analyze and predict the effect of parameter changes on algorithm performance
- Assess and validate the developed algorithms in terms of results

### Module 7. Robot Visual Perception Systems with Automatic Learning
- Master the machine learning techniques most widely used today in academia and industry
- Delve into the architectures of neural networks to apply them effectively in real problems
- Reuse existing neural networks in new applications using transfer learning
- Identify new fields of application of generative neural networks
- Analyze the use of learning techniques in other fields of robotics such as localization and mapping
- Develop current technologies in the cloud to develop neural network-based technologies
- Examine the deployment of vision learning systems in real and embedded systems

### Module 8. Visual SLAM. Robot Localization and Simultaneous Mapping by Computer Vision Techniques
- Specify the basic structure of a Simultaneous Localization and Mapping (SLAM) system
- Identify the basic sensors used in Simultaneous Localization and Mapping (visual SLAM)
- Establish the boundaries and capabilities of visual SLAM
- Compile the basic notions of projective and epipolar geometry to understand imaging projection processes
- Identify the main visual SLAM technologies: Gaussian Filters, Optimization and Loop Closure Detection
- Describe in detail the operation of the main visual SLAM algorithms
- Analyze how to carry out the tuning and parameterization of SLAM algorithms

### Module 9. Application of Virtual and Augmented Reality Technologies to Robotics

- Determine the difference among the different types of realities
- Analyze the current standards for modeling virtual elements
- Examine the most commonly used peripherals in immersive environments
- Define geometric models of robots
- Assess physics engines for dynamic and kinematic modeling of robots
- Develop Virtual Reality and Augmented Reality projects

### Module 10. Robot Communication and Interaction Systems

- Analyze current natural language processing strategies: heuristic, stochastic, neural network-based, reinforcement-based learning
- Assess the benefits and weaknesses of developing cross-cutting, or situation-focused, interaction systems
- Identify the environmental problems to be solved in order to achieve effective communication with the robot
- Establish the tools needed to manage the interaction and discern the type of dialogue initiative to be pursued
- Combine pattern recognition strategies to infer the intentions of the interlocutor and respond in the best way to them
- Determine the optimal expressiveness of the robot according to its functionality and environment, and apply emotional analysis techniques to adapt its response
- Propose hybrid strategies for interaction with the robot: vocal, tactile and visual

03
# Skills

The skills that the Robotics engineer must develop are multiple, so this Professional Master's Degree focuses on vital issues such as robot planning algorithms, automatic control systems, artificial intelligence applications and advanced robot design. All this in order to gain not only a global understanding of all that modern robotics encompasses, but also to acquire and hone the skills necessary to undertake the most ambitious projects in this field.


*You will have a set of skills in Robotics highly sought after in the most important projects and industries internationally"*

## General Skills

- Master today's most widely used virtualization tools in use today
- Design virtual robotic environments
- Examine the techniques and algorithms underlying any AI algorithm
- Design, develop, implement and validate perceptual systems for robotics

*You will hone your strategic, mathematical and analytical determination to take on the creation and definition of complex robotics projects"*

## Specific Skills

- Identify multimodal interaction systems and their integration with the rest of the robot components
- Implement own virtual and augmented reality projects
- Propose applications in real systems
- Examine, analyze and develop existing methods for path planning by a mobile robot and a manipulator
- Analyze and define strategies for the implementation and maintenance of perception systems
- Determine strategies for integration of a dialog system as part of basic robot behavior
- Analyze programming and device configuration skills
- Examine control strategies used in different robotic systems

04

# Course Management

Advances in robotics are unstoppable and professionals in this field are continually renewing their knowledge and acquiring new ones to further advance their careers. For this reason, TECH has called upon active Robotics experts with vast experience in multidisciplinary projects of all kinds. Therefore, all the content provided by the teaching team is based on the latest robotic news, including cutting-edge scientific postulates and a practical approach to the current theoretical framework.

*Succeed with the best and acquire the knowledge and skills you need to embark on the robotics industry"*

## Management

### Dr. Ramón Fabresse, Felipe

- Senior Software Engineer at Acurable
- NLP Software Engineer at Intel Corporation
- Software Engineer in CATEC, Indisys
- Researcher in Aerial Robotics at the University of Seville
- PhD Cum Laude in Robotics, Autonomous Systems and Telerobotics at the University of Seville
- Degree in Computer Engineering at the University of Seville
- Professional Master's Degree in Robotics, Automation and Telematics at the University of Seville

## Professors

### Dr. Íñigo Blasco, Pablo

- Software Engineer at PlainConcepts
- Founder of Intelligent Behavior Robots
- Robotics Engineer at CATEC Advanced Center for Aerospace Technologies
- Developer and Consultant at Syderis
- PhD in Industrial Informatics Engineering at the University of Seville
- Degree in Computer Engineering at the University of Seville
- Professional Master's Degree in Software Engineering and Technology

### Mr. Campos Ortiz, Roberto

- Software Engineer Quasar Scence Resources
- Software Engineer at the European Space Agency (ESA-ESAC) for the Solar Orbiter mission
- Content creator and Artificial Intelligence expert in the course: "Artificial Intelligence: The technology of the present-future" for the Andalusian Regional Government. Euroformac Group
- Quantum Computing Scientist Zapata Computing Inc
- Graduated in Computer Engineering at Carlos III University
- Master in Computer Science and Technology at Carlos III University

### Mr. Rosado Junquera, Pablo J

- Engineer Specialist in Robotics and Automatization
- R&D Automation and Control Engineer at Becton Dickinson & Company
- Amazon Logistic Control Systems Engineer at Dematic
- Automation and Control Engineer at Aries Ingeniería y Sistemas
- Graduate in Energy and Materials Engineering at Rey Juan Carlos University
- Master's Degree in Robotics and Automation at the Polytechnic University of Madrid
- Master's Degree in Industrial Engineering at the University of Alcalá

### Dr. Jiménez Cano, Antonio Enrique

- Engineer at Aeronautical Data Fusion Engineer
- Researcher in European projects (ARCAS, AEROARMS and AEROBI) at the University of Seville
- Researcher in Navigation Systems at CNRS-LAAS
- LAAS MBZIRC2020 System Developer
- Group of Robotics, Vision and Control (GRVC) of the University of Seville
- PhD in Automatics, Electronics and Telecommunications at the University of Seville
- Graduated in Automatic Engineering and Industrial Electronics at the University of Seville
- Degree in Technical Engineering in Computer Systems at the University of Seville

### Dr. Alejo Teissière, David

- Telecommunications Engineer.with Specialization in Robotics
- Postdoctoral Researcher in the European projects SIAR and NIx ATEX at Pablo de Olavide University
- Systems Developer at Aertec
- PhD in Automation, Robotics and Telematics at the University of Seville
- Graduated in Telecommunication Engineering at the University of Seville
- Master's Degree in Automation, Robotics and Telematics from the University of Seville

### Dr. Pérez Grau, Francisco Javier

- Head of the Perception and Software Unit at CATEC
- R&D Project Manager at CATEC
- R&D Project Engineer at CATEC
- Associate Professor at the University of Cadiz
- Associate Professor at the University International of Andalucia
- Researcher in the Robotics and Perception group at the University of Zurich
- Researcher at the Australian Centre for Field Robotics at the University of Sydney
- PhD in Robotics and Autonomous Systems from the University of Seville
- Graduate in Telecommunications Engineering and Computer and Network Engineering from the University of Seville

### Dr. Ramon Soria, Pablo

- Computational Vision Engineer at Meta
- Applied Science Team Leader and Senior Software Engineer at Vertical Engineering Solutions
- CEO and founder of Domocracy
- ACFR Researcher (Australia)
- Researcher in the GRIFFIN and HYFLIERS projects at the University of Seville
- PhD in Computational Vision for Robotics at the University of Seville
- Graduated in Industrial Engineer, Robotics and Automatization from University of Seville

### Dr. Caballero Benítez, Fernando

- Researcher in the European projects COMETS, AWARE, ARCAS and SIAR
- Degree in Telecommunications Engineering from the University of Seville
- PhD in Telecommunications Engineering at the University of Seville
- Full Professor of Systems Engineering and Automatics at the University of Seville
- Associate editor of the journal Robotics and Automation Letters

### Dr. Lucas Cuesta, Juan Manuel

- Senior Software Engineer and Analyst at Indizen– Believe in Talent
- Senior Software Engineer and Analyst at Krell Consulting and IMAGiNA Artificial Intelligence
- Software Engineer at Intel Corporation
- Software Engineer at Intelligent Dialogue Systems
- PhD in Electronic Systems Engineering for Intelligent Environments at the Polytechnic University of Madrid
- Graduate in Telecommunications Engineering at the Polytechnic University of Madrid
- Master's Degree in Electronic Systems Engineering for Intelligent Environments at the Polytechnic University of Madrid



*Enroll now and don't miss the opportunity to delve into the application of robotics to virtual and augmented reality technologies, with virtual sensors and mixed mobile applications"*

# 05 Structure and Content

The teaching team involved in the design of the entire syllabus has used the Relearning methodology, favoring a progressive and natural teaching for the whole program. This is achieved through a reiteration of the most important key concepts in robotics and advanced engineering, so that the student does not have to spend long hours of study to acquire this knowledge.

*You have within your reach the key to direct your engineering career towards the field of robotics. Don't waste this oportunity and enroll now"*

## **Module 1.** Robotics: Robot Design and Modeling

1.1. Robotics and Industry 4.0
- 1.1.1. Robotics and Industry 4.0
- 1.1.2. Application Fields and Use Cases
- 1.1.3. Sub-Areas of Specialization in Robotics

1.2. Robot Hardware and Software Architectures
- 1.2.1. Hardware Architectures and Real-Time
- 1.2.2. Robot Software Architectures
- 1.2.3. Communication Models and Middleware Technologies
- 1.2.4. Robot Operating System (ROS) Software Integration

1.3. Mathematical Modeling of Robots
- 1.3.1. Mathematical Representation of Rigid Solids
- 1.3.2. Rotations and Translations
- 1.3.3. Hierarchical State Representation
- 1.3.4. Distributed Representation of the State in ROS (TF Library)

1.4. Robot Kinematics and Dynamics
- 1.4.1. Kinematics
- 1.4.2. Dynamics
- 1.4.3. Underactuated Robots
- 1.4.4. Redundant Robots

1.5. Robot Modeling and Simulation
- 1.5.1. Robot Modeling Technologies
- 1.5.2. Robot Modeling with URDF
- 1.5.3. Robot Simulation
- 1.5.4. Modeling with Gazebo Simulator

1.6. Robot Manipulators
- 1.6.1. Types of Manipulator Robots
- 1.6.2. Kinematics
- 1.6.3. Dynamics
- 1.6.4. Simulation

1.7. Terrestrial Mobile Robots
- 1.7.1. Types of Terrestrial Mobile Robots
- 1.7.2. Kinematics
- 1.7.3. Dynamics
- 1.7.4. Simulation

1.8. Aerial Mobile Robots
- 1.8.1. Types of Aerial Mobile Robots
- 1.8.2. Kinematics
- 1.8.3. Dynamics
- 1.8.4. Simulation

1.9. Aquatic Mobile Robots
- 1.9.1. Types of Aquatic Mobile Robots
- 1.9.2. Kinematics
- 1.9.3. Dynamics
- 1.9.4. Simulation

1.10. Bioinspired Robots
- 1.10.1. Humanoids
- 1.10.2. Robots with Four or More Legs
- 1.10.3. Modular Robots
- 1.10.4. Robots with Flexible Parts (Soft-Robotics)

## **Module 2.** Intelligent Agents. Application of Artificial Intelligence to Robots and Softbots

2.1. Intelligent Agents and Artificial Intelligence
- 2.1.1. Intelligent Robots. Artificial Intelligence
- 2.1.2. Intelligent Agents
  - 2.1.2.1. Hardware Agents Robots
  - 2.1.2.2. Software Agents. Softbots
- 2.1.3. Robotics Applications

2.2. Brain-Algorithm Connection
- 2.2.1. Biological Inspiration of Artificial Intelligence
- 2.2.2. Reasoning Implemented in Algorithms. Typology
- 2.2.3. Explainability of Results in Artificial Intelligence Algorithms
- 2.2.4. Evolution of Algorithms up to Deep Learning

2.3. Search Algorithms in the Solution Space
 2.3.1. Elements in Solution Space Searches
 2.3.2. Solution Search Algorithms in Artificial Intelligence Problems
 2.3.3. Applications of Search and Optimization Algorithms
 2.3.4. Search Algorithms Applied to Machine Learning
2.4. Machine Learning
 2.4.1. Machine Learning
 2.4.2. Supervised Learning Algorithms
 2.4.3. Unsupervised Learning Algorithms
 2.4.4. Reinforcement Learning Algorithms
2.5. Supervised Learning
 2.5.1. Supervised Learning Methods
 2.5.2. Decision Trees for Classification
 2.5.3. Support Vector Machines
 2.5.4. Artificial Neural Networks
 2.5.5. Applications of Supervised Learning
2.6. Unsupervised Learning
 2.6.1. Unsupervised Learning
 2.6.2. Kohonen Networks
 2.6.3. Self-Organizing Maps
 2.6.4. K-Means Algorithm
2.7. Reinforcement Learning
 2.7.1. Reinforcement Learning
 2.7.2. Agents Based on Markov Processes
 2.7.3. Reinforcement Learning Algorithms
 2.7.4. Reinforcement Learning Applied to Robotics
2.8. Artificial Neural Networks and Deep Learning
 2.8.1. Artificial Neural Networks. Typology
 2.8.2. Applications of Neural Networks
 2.8.3. Transformation from Machine Learning to Deep Learning
 2.8.4. Deep Learning Applications
2.9. Probabilistic Inference
 2.9.1. Probabilistic Inference
 2.9.2. Types of Inference and Method Definition
 2.9.3. Bayesian Inference as a Case Study
 2.9.4. Nonparametric Inference Techniques
 2.9.5. Gaussian Filters
2.10. From Theory to Practice: Developing an Intelligent Robotic Agent
 2.10.1. Inclusion of Supervised Learning Modules in a Robotic Agent
 2.10.2. Inclusion of Reinforcement Learning Modules in a Robotic Agent
 2.10.3. Architecture of a Robotic Agent Controlled by Artificial Intelligence
 2.10.4. Professional Tools for the Implementation of the Intelligent Agent
 2.10.5. Phases of the Implementation of AI Algorithms in Robotic Agents

## **Module 3.** Robotics in the Automation of Industrial Processes

3.1. Design of Automated Systems
 3.1.1. Hardware Architectures
 3.1.2. Programmable Logic Controllers
 3.1.3. Industrial Communication Networks
3.2. Advanced Electrical Design I: Automation
 3.2.1. Design of Electrical Panels and Symbology
 3.2.2. Power and Control Circuits. Harmonics
 3.2.3. Protection and Grounding Elements
3.3. Advanced Electrical Design II: Determinism and Safety
 3.3.1. Machine Safety and Redundancy
 3.3.2. Safety Relays and Triggers
 3.3.3. Safety PLCs
 3.3.4. Safe Networks
3.4. Electrical Actuation
 3.4.1. Motors and Servomotors
 3.4.2. Frequency Inverters and Controllers
 3.4.3. Electrically Actuated Industrial Robotics

3.5. Hydraulic and Pneumatic Actuation
  3.5.1. Hydraulic Design and Symbology
  3.5.2. Pneumatic Design and Symbology
  3.5.3. ATEX Environments in Automation
3.6. Transducers in Robotics and Automation
  3.6.1. Position and Velocity Measurement
  3.6.2. Force and Temperature Measurement
  3.6.3. Presence Measurement
  3.6.4. Vision Sensors
3.7. Programming and Configuration of Programmable Logic Controllers PLCs
  3.7.1. PLC Programming: LD
  3.7.2. PLC Programming: ST
  3.7.3. PLC Programming: FBD and CFC
  3.7.4. PLC Programming: SFC
3.8. Programming and Configuration of Equipment in Industrial Plants
  3.8.1. Programming of Drives and Controllers
  3.8.2. HMI Programming
  3.8.3. Programming of Manipulator Robots
3.9. Programming and Configuration of Industrial Computer Equipment
  3.9.1. Programming of Vision Systems
  3.9.2. SCADA/Software Programming
  3.9.3. Network Configuration
3.10. Automation Implementation
  3.10.1. State Machine Design
  3.10.2. Implementation of State Machines in PLCs
  3.10.3. Implementation of Analog PID Control Systems in PLCs
  3.10.4. Automation Maintenance and Code Hygiene
  3.10.5. Automation and Plant Simulation

## **Module 4.** Automatic Control Systems in Robotics

4.1. Analysis and Design of Nonlinear Systems
  4.1.1. Analysis and Modeling of Nonlinear Systems
  4.1.2. Feedback Control
  4.1.3. Linearization by Feedback



4.2. Design of Control Techniques for Advanced Non-linear Systems
- 4.2.1. Sliding Mode control
- 4.2.2. Lyapunov and Backstepping Control
- 4.2.3. Control Based on Passivity

4.3. Control Architectures
- 4.3.1. The Robotics Paradigm
- 4.3.2. Control Architectures
- 4.3.3. Applications and Examples of Control Architectures

4.4. Motion Control for Robotic Arms
- 4.4.1. Kinematic and Dynamic Modeling
- 4.4.2. Control in Joint Space
- 4.4.3. Control in Operational Space

4.5. Actuator Force Control
- 4.5.1. Force Control
- 4.5.2. Impedance Control
- 4.5.3. Hybrid Control

4.6. Terrestrial Mobile Robots
- 4.6.1. Equations of Motion
- 4.6.2. Control Techniques for Terrestrial Robots
- 4.6.3. Mobile Manipulators

4.7. Aerial Mobile Robots
- 4.7.1. Equations of Motion
- 4.7.2. Control Techniques in Aerial Robots
- 4.7.3. Aerial Manipulation

4.8. Control Based on Machine Learning Techniques
- 4.8.2. Control Using Supervised Learning
- 4.8.3. Control Using Reinforced Learning
- 4.8.4. Control by Unsupervised Learning

4.9. Vision-Based Control
- 4.9.1. Position-Based Visual Servoing
- 4.9.2. Image-Based Visual Servoing
- 4.9.3. Hybrid Visual Servoing

4.10. Predictive Control
- 4.10.1. Models and State Estimation
- 4.10.2. MPC Applied to Mobile Robots
- 4.10.3. MPC Applied to UAVs

## Module 5. Robot Planning Algorithms

5.1. Classical Planning Algorithms
- 5.1.1. Discrete Planning: State Space
- 5.1.2. Planning Problems in Robotics. Robotic Systems Models
- 5.1.3. Classification of Planners

5.2. The Trajectory Planning Problem in Mobile Robots
- 5.2.1. Forms of Environment Representation: Graphs
- 5.2.2. Search Algorithms in Graphs
- 5.2.3. Introduction of Costs in Networks
- 5.2.4. Search Algorithms in Heavy Networks
- 5.2.5. Algorithms with any Angle Approach

5.3. Planning in High Dimensional Robotic Systems
- 5.3.1. High Dimensionality Robotics Problems: Manipulators
- 5.3.2. Direct/Inverse Kinematic Model
- 5.3.3. Sampling Planning Algorithms PRM and RRT
- 5.3.4. Planning Under Dynamic Constraints

5.4. Optimal Sampling Planning
- 5.4.1. Problem of Sampling-Based Planners
- 5.4.2. RRT Probabilistic Optimality Concept
- 5.4.3. Reconnection Step: Dynamic Constraints
- 5.4.4. CForest. Parallelizing Planning

5.5. Real Implementation of a Motion Planning System
- 5.5.1. Global Planning Problem. Dynamic Environments
- 5.5.2. Cycle of Action, Sensorization. Acquisition of Information from the Environment
- 5.5.3. Local and Global Planning

5.6. Coordination in Multi-Robot Systems I: Centralized System
- 5.6.1. Multirobot Coordination Problem
- 5.6.2. Collision Detection and Resolution: Trajectory Modification with Genetic Algorithms
- 5.6.3. Other Bio-Inspired Algorithms: Particle Swarm and Fireworks
- 5.6.4. Collision Avoidance by Choice of Maneuver Algorithm

5.7. Coordination in Multi-Robot Systems II: Distributed Approaches I
- 5.7.1. Use of Complex Objective Functions
- 5.7.2. Pareto Front
- 5.7.3. Multi-Objective Evolutionary Algorithms

5.8. Coordination in Multi-Robot Systems III: Distributed Approaches II
- 5.8.1. Order 1 Planning Systems
- 5.8.2. ORCA Algorithm
- 5.8.3. Addition of Kinematic and Dynamic Constraints in ORCA

5.9. Decision Planning Theory
- 5.9.1. Decision Theory
- 5.9.2. Sequential Decision Systems
- 5.9.3. Sensors and Information Spaces
- 5.9.4. Planning for Uncertainty in Sensing and Actuation

5.10. Reinforcement Learning Planning Systems
- 5.10.1. Obtaining the Expected Reward of a System
- 5.10.2. Mean Reward Learning Techniques
- 5.10.3. Inverse Reinforcement Learning

## Module 6. Artificial Vision Techniques in Robotics: Image Processing and Analysis

6.1. Computer Vision
- 6.1.1. Computer Vision
- 6.1.2. Elements of a Computer Vision System
- 6.1.3. Mathematical Tools

6.2. Optical Sensors for Robotics
- 6.2.1. Passive Optical Sensors
- 6.2.2. Active Optical Sensors
- 6.2.3. Non-Optical Sensors

6.3. Image Acquisition
  6.3.1. Image Representation
  6.3.2. Color Space
  6.3.3. Digitizing Process
6.4. Image Geometry
  6.4.1. Lens Models
  6.4.2. Camera Models
  6.4.3. Camera Calibration
6.5. Mathematical Tools
  6.5.1. Histogram of an Image
  6.5.2. Convolution
  6.5.3. Fourier Transform
6.6. Image Preprocessing
  6.6.1. Noise Analysis
  6.6.2. Image Smoothing
  6.6.3. Image Enhancement
6.7. Image Segmentation
  6.7.1. Contour-Based Techniques
  6.7.2. Histogram-Based Techniques
  6.7.3. Morphological Operations
6.8. Image Feature Detection
  6.8.1. Point of Interest Detection
  6.8.2. Feature Descriptors
  6.8.3. Feature Matching
6.9. 3D Vision Systems
  6.9.1. 3D Perception
  6.9.2. Feature Matching between Images
  6.9.3. Multiple View Geometry
6.10. Computer Vision based Localization
  6.10.1. The Robot Localization Problem
  6.10.2. Visual Odometry
  6.10.3. Sensory Fusion

## **Module 7.** Robot Visual Perception Systems with Automatic Learning

7.1. Unsupervised Learning Methods applied to Computer Vision
  7.1.1. Clustering
  7.1.2. PCA
  7.1.3. Nearest Neighbors
  7.1.4. Similarity and Matrix Decomposition
7.2. Supervised Learning Methods Applied to Artificial Vision
  7.2.1. “Bag of words” Concept
  7.2.2. Support Vector Machine
  7.2.3. Latent Dirichlet Allocation
  7.2.4. Neural Networks
7.3. Deep Neural Networks: Structures, Backbones and Transfer Learning
  7.3.1. Feature Generating Layers
    7.3.3.1. VGG
    7.3.3.2. Densenet
    7.3.3.3. ResNet
    7.3.3.4. Inception
    7.3.3.5. GoogLeNet
  7.3.2. Transfer Learning
  7.3.3. The Data Preparation for Training
7.4. Artificial Vision with Deep Learning I: Detection and Segmentation
  7.4.1. YOLO and SSD Differences and Similarities
  7.4.2. Unet
  7.4.3. Other Structures
7.5. Computer Vision with Deep Learning II: Generative Adversarial Networks
  7.5.1. Image Super-Resolution Using GAN
  7.5.2. Creation of Realistic Images
  7.5.3. Scene Understanding
7.6. Learning Techniques for Localization and Mapping in Mobile Robotics
  7.6.1. Loop Closure Detection and Relocation
  7.6.2. Magic Leap. Super Point and Super Glue
  7.6.3. Depth from Monocular

7.7. Bayesian Inference and 3D Modeling
    7.7.1. Bayesian Models and "Classical" Learning
    7.7.2. Implicit Surfaces with Gaussian Processes (GPIS)
    7.7.3. 3D Segmentation Using GPIS
    7.7.4. Neural Networks for 3D Surface Modeling
7.8. End-to-End Applications of Deep Neural Networks
    7.8.1. End-to-End System. Example of Person Identification
    7.8.2. Object Manipulation with Visual Sensors
    7.8.3. Motion Generation and Planning with Visual Sensors
7.9. Cloud Technologies to Accelerate the Development of Deep Learning Algorithms
    7.9.1. Use of GPUs for Deep Learning
    7.9.2. Agile Development with Google Colab
    7.9.3. Remote GPUs, Google Cloud and AWS
7.10. Deployment of Neural Networks in Real Applications
    7.10.1. Embedded Systems
    7.10.2. Deployment of Neural Networks. Use
    7.10.3. Network Optimizations in Deployment, Example with TensorRT

## **Module 8.** Visual SLAM. Robot Localization and Simultaneous Mapping by Artificial Vision Techniques

8.1. Simultaneous Localization and Mapping (SLAM)
    8.1.1. Simultaneous Localization and Mapping. SLAM
    8.1.2. SLAM Applications
    8.1.3. SLAM Operation
8.2. Projective Geometry
    8.2.1. Pin-Hole Model
    8.2.2. Estimation of Intrinsic Parameters of a Chamber
    8.2.3. Homography, Basic Principles and Estimation
    8.2.4. Fundamental Matrix, Principles and Estimation
8.3. Gaussian Filters
    8.3.1. Kalman Filter
    8.3.2. Information Filter
    8.3.3. Adjustment and Parameterization of Gaussian Filters



8.4. Stereo EKF-SLAM
- 8.4.1. Stereo Camera Geometry
- 8.4.2. Feature Extraction and Search
- 8.4.3. Kalman Filter for Stereo SLAM
- 8.4.4. Stereo EKF-SLAM Parameter Setting

8.5. Monocular EKF-SLAM
- 8.5.1. EKF-SLAM Landmark Parameterization
- 8.5.2. Kalman Filter for Monocular SLAM
- 8.5.3. Monocular EKF-SLAM Parameter Tuning

8.6. Loop Closure Detection
- 8.6.1. Brute Force Algorithm
- 8.6.2. FABMAP
- 8.6.3. Abstraction Using GIST and HOG
- 8.6.4. Deep Learning Detection

8.7. Graph-SLAM
- 8.7.1. Graph-SLAM
- 8.7.2. RGBD-SLAM
- 8.7.3. ORB-SLAM

8.8. Direct Visual SLAM
- 8.8.1. Analysis of the Direct Visual SLAM Algorithm
- 8.8.2. LSD-SLAM
- 8.8.3. SVO

8.9. Visual Inertial SLAM
- 8.9.1. Integration of Inertial Measurements
- 8.9.2. Low Coupling: SOFT-SLAM
- 8.9.3. High Coupling: Vins-Mono

8.10. Other SLAM Technologies
- 8.10.1. Applications Beyond Visual SLAM
- 8.10.2. Lidar-SLAM
- 8.10.2. Range-only SLAM

**Module 9.** Application of Virtual and Augmented Reality Technologies to Robotics

9.1. Immersive Technologies in Robotics
- 9.1.1. Virtual Reality in Robotics
- 9.1.2. Augmented Reality in Robotics
- 9.1.3. Mixed Reality in Robotics
- 9.1.4. Difference between Realities

9.2. Construction of Virtual Environments
- 9.2.1. Materials and Textures
- 9.2.2. Lighting
- 9.2.3. Virtual Sound and Smell

9.3. Robot Modeling in Virtual Environments
- 9.3.1. Geometric Modeling
- 9.3.2. Physical Modeling
- 9.3.3. Model Standardization

9.4. Modeling of Robot Dynamics and Kinematics Virtual Physical Engines
- 9.4.1. Physical Motors. Typology
- 9.4.2. Configuration of a Physical Engine
- 9.4.3. Physical Motors in the Industry

9.5. Platforms, Peripherals and Tools Most Commonly Used in Virtual Reality
- 9.5.1. Virtual Reality Viewers
- 9.5.2. Interaction Peripherals
- 9.5.3. Virtual Sensors

9.6. Augmented Reality Systems
- 9.6.1. Insertion of Virtual Elements into Reality
- 9.6.2. Types of Visual Markers
- 9.6.3. Augmented Reality Technologies

9.7. Metaverse: Virtual Environments of Intelligent Agents and People
- 9.7.1. Avatar Creation
- 9.7.2. Intelligent Agents in Virtual Environments
- 9.7.3. Construction of Multi-User Environments for VR/AR

9.8. Creation of Virtual Reality Projects for Robotics
- 9.8.1. Phases of Development of a Virtual Reality Project
- 9.8.2. Deployment of Virtual Reality Systems
- 9.8.3. Virtual Reality Resources

9.9. Creating Augmented Reality Projects for Robotics
- 9.9.1. Phases of Development of an Augmented Reality Project
- 9.9.2. Deployment of Augmented Reality Projects
- 9.9.3. Augmented Reality Resources

9.10. Robot Teleoperation with Mobile Devices
- 9.10.1. Mixed Reality on Mobile Devices
- 9.10.2. Immersive Systems using Mobile Device Sensors
- 9.10.3. Examples of Mobile Projects

## **Module 10.** Robot Communication and Interaction Systems

10.1. Speech Recognition: Stochastic Systems
- 10.1.1. Acoustic Speech Modeling
- 10.1.2. Hidden Markov Models
- 10.1.3. Linguistic Speech Modeling: N-Grams, BNF Grammars

10.2. Speech Recognition Deep Learning
- 10.2.1. Deep Neural Networks
- 10.2.2. Recurrent Neural Networks
- 10.2.3. LSTM Cells

10.3. Speech Recognition: Prosody and Environmental Effects
- 10.3.1. Ambient Noise
- 10.3.2. Multi-Speaker Recognition
- 10.3.3. Speech Pathologies

10.4. Natural Language Understanding: Heuristic and Probabilistic Systems
- 10.4.1. Syntactic-Semantic Analysis: Linguistic Rules
- 10.4.2. Comprehension Based on Heuristic Rules
- 10.4.3. Probabilistic Systems: Logistic Regression and SVM
- 10.4.4. Understanding Based on Neural Networks

10.5. Dialog Management: Heuristic/Probabilistic Strategies
- 10.5.1. Interlocutor's Intention
- 10.5.2. Template-Based Dialog
- 10.5.3. Stochastic Dialog Management: Bayesian Networks

10.6. Dialog Management: Advanced Strategies
- 10.6.1. Reinforcement-Based Learning Systems
- 10.6.2. Neural Network-Based Systems
- 10.6.3. From Speech to Intention in a Single Network

10.7. Response Generation and Speech Synthesis
- 10.7.1. Response Generation: From Idea to Coherent Text
- 10.7.2. Speech Synthesis by Concatenation
- 10.7.3. Stochastic Speech Synthesis

10.8. Dialog Adaptation and Contextualization
- 10.8.1. Dialog Initiative
- 10.8.2. Adaptation to the Speaker
- 10.8.3. Adaptation to the Context of the Dialogue

10.9. Robots and Social Interactions: Emotion Recognition, Synthesis and Expression
- 10.9.1. Artificial Voice Paradigms: Robotic Voice and Natural Voice
- 10.9.2. Emotion Recognition and Sentiment Analysis
- 10.9.3. Emotional Voice Synthesis

10.10. Robots and Social Interactions: Advanced Multimodal Interfaces
- 10.10.1. Combination of Vocal and Tactile Interfaces
- 10.10.2. Sign Language Recognition and Translation
- 10.10.3. Visual Avatars: Voice to Sign Language Translation

# 06
# Methodology

This academic program offers students a different way of learning. Our methodology uses a cyclical learning approach: **Relearning.**
This teaching system is used, for example, in the most prestigious medical schools in the world, and major publications such as the **New England Journal of Medicine** have considered it to be one of the most effective.

*Discover Relearning, a system that abandons conventional linear learning, to take you through cyclical teaching systems: a way of learning that has proven to be extremely effective, especially in subjects that require memorization"*

## Case Study to contextualize all content

Our program offers a revolutionary approach to developing skills and knowledge. Our goal is to strengthen skills in a changing, competitive, and highly demanding environment.

*At TECH, you will experience a learning methodology that is shaking the foundations of traditional universities around the world"*


*You will have access to a learning system based on repetition, with natural and progressive teaching throughout the entire syllabus.*

*The student will learn to solve complex situations in real business environments through collaborative activities and real cases.*

## A learning method that is different and innovative

This TECH program is an intensive educational program, created from scratch, which presents the most demanding challenges and decisions in this field, both nationally and internationally. This methodology promotes personal and professional growth, representing a significant step towards success. The case method, a technique that lays the foundation for this content, ensures that the most current economic, social and professional reality is taken into account.

*Our program prepares you to face new challenges in uncertain environments and achieve success in your career"*

The case method is the most widely used learning system in the best faculties in the world. The case method was developed in 1912 so that law students would not only learn the law based on theoretical content. It consisted of presenting students with real-life, complex situations for them to make informed decisions and value judgments on how to resolve them. In 1924, Harvard adopted it as a standard teaching method.

What should a professional do in a given situation? This is the question that you are presented with in the case method, an action-oriented learning method. Throughout the program, the studies will be presented with multiple real cases. They will have to combine all their knowledge and research, and argue and defend their ideas and decisions.

## Relearning Methodology

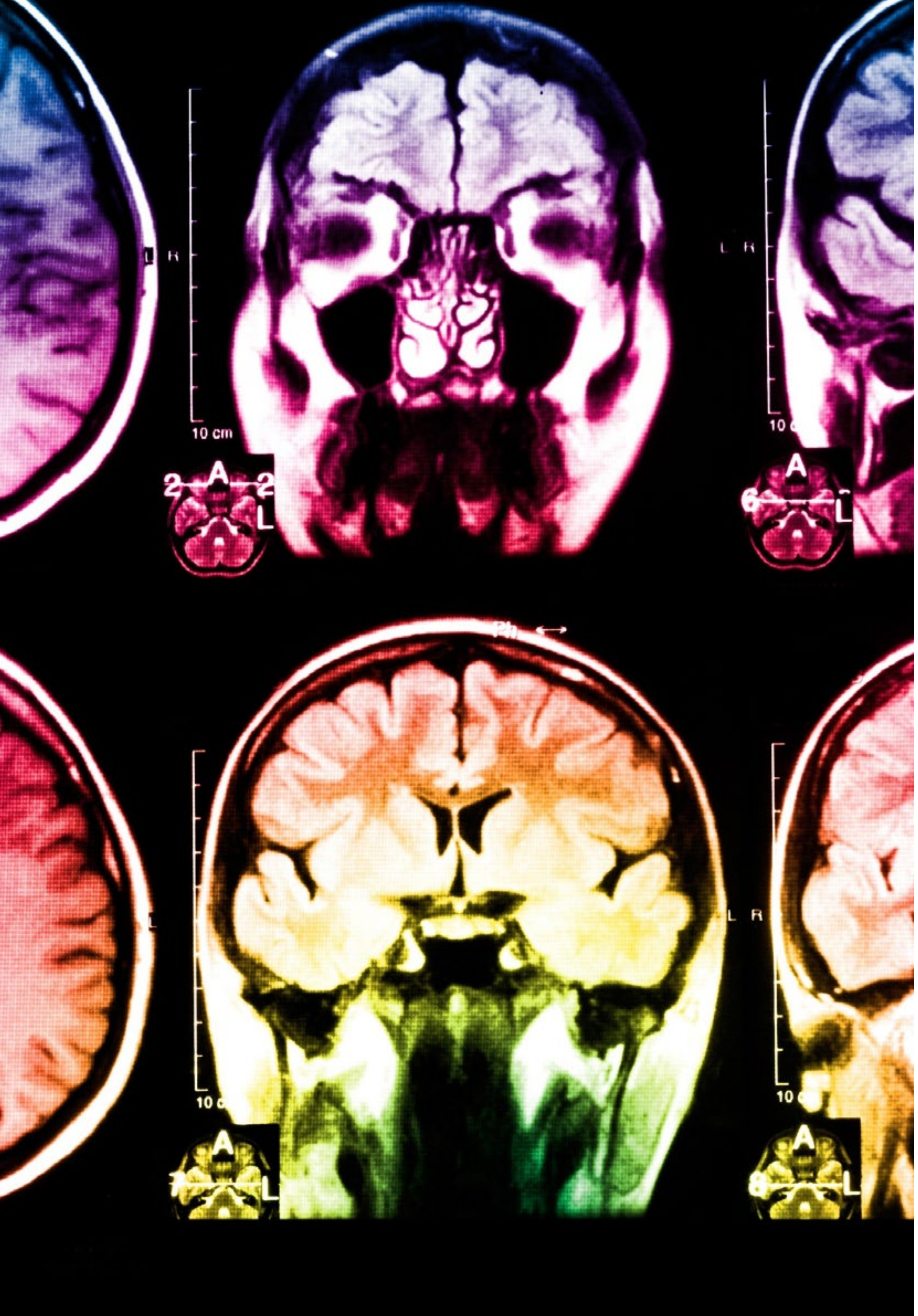
TECH effectively combines the Case Study methodology with a 100% online learning system based on repetition, which combines 8 different teaching elements in each lesson.

We enhance the Case Study with the best 100% online teaching method: Relearning.

*In 2019, we obtained the best learning results of all online universities in the world.*


At TECH, you will learn using a cutting-edge methodology designed to train the executives of the future. This method, at the forefront of international teaching, is called Relearning.

Our university is the only one in the world authorized to employ this successful method. In 2019, we managed to improve our students' overall satisfaction levels (teaching quality, quality of materials, course structure, objectives...) based on the best online university indicators.



In our program, learning is not a linear process, but rather a spiral (learn, unlearn, forget, and re-learn). Therefore, we combine each of these elements concentrically. This methodology has trained more than 650,000 university graduates with unprecedented success in fields as diverse as biochemistry, genetics, surgery, international law, management skills, sports science, philosophy, law, engineering, journalism, history, and financial markets and instruments. All this in a highly demanding environment, where the students have a strong socio-economic profile and an average age of 43.5 years.

*Relearning will allow you to learn with less effort and better performance, involving you more in your training, developing a critical mindset, defending arguments, and contrasting opinions: a direct equation for success.*

From the latest scientific evidence in the field of neuroscience, not only do we know how to organize information, ideas, images and memories, but we know that the place and context where we have learned something is fundamental for us to be able to remember it and store it in the hippocampus, to retain it in our long-term memory.

In this way, and in what is called neurocognitive context-dependent e-learning, the different elements in our program are connected to the context where the individual carries out their professional activity.

## This program offers the best educational material, prepared with professionals in mind:

### Study Material

All teaching material is produced by the specialists who teach the course, specifically for the course, so that the teaching content is highly specific and precise.

These contents are then applied to the audiovisual format, to create the TECH online working method. All this, with the latest techniques that offer high quality pieces in each and every one of the materials that are made available to the student.

### Classes

There is scientific evidence suggesting that observing third-party experts can be useful.

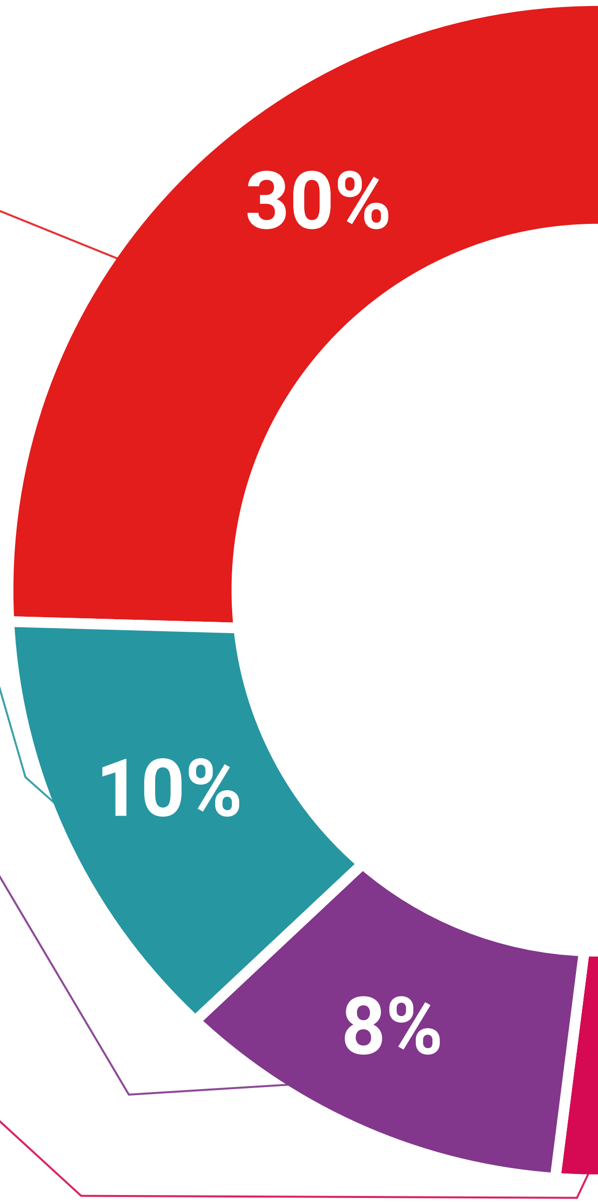
Learning from an Expert strengthens knowledge and memory, and generates confidence in future difficult decisions.

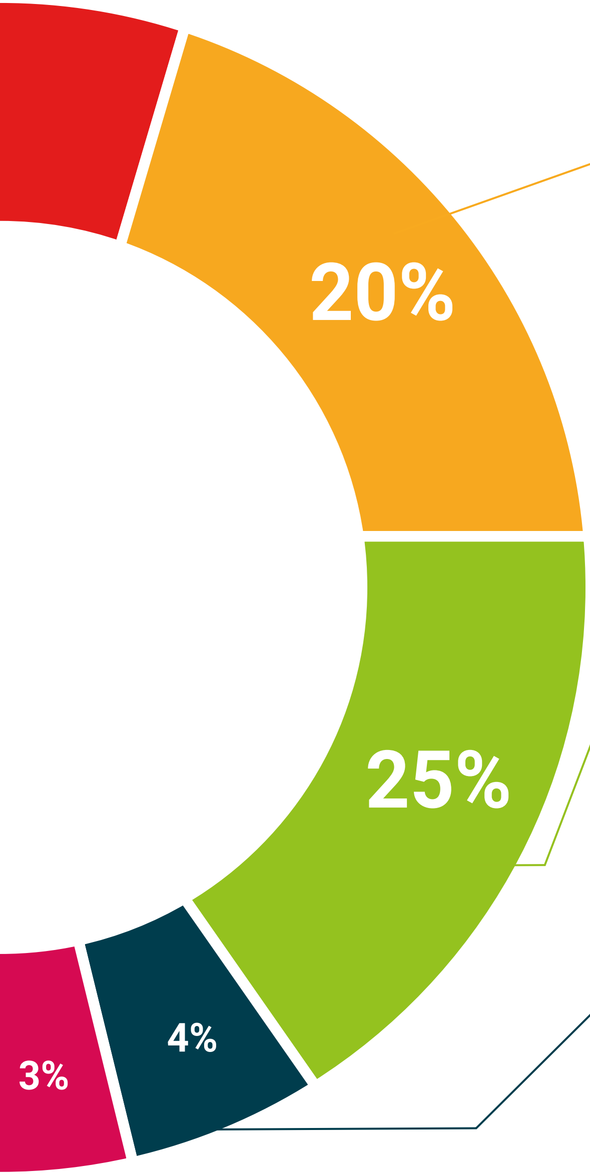
### Practising Skills and Abilities

They will carry out activities to develop specific skills and abilities in each subject area. Exercises and activities to acquire and develop the skills and abilities that a specialist needs to develop in the context of the globalization that we are experiencing.

### Additional Reading

Recent articles, consensus documents and international guidelines, among others. In TECH's virtual library, students will have access to everything they need to complete their course.






**Case Studies**

Students will complete a selection of the best case studies chosen specifically for this program. Cases that are presented, analyzed, and supervised by the best specialists in the world.

**Interactive Summaries**

The TECH team presents the contents attractively and dynamically in multimedia lessons that include audio, videos, images, diagrams, and concept maps in order to reinforce knowledge.

This exclusive educational system for presenting multimedia content was awarded by Microsoft as a "European Success Story".

**Testing & Retesting**

We periodically evaluate and re-evaluate students' knowledge throughout the program, through assessment and self-assessment activities and exercises, so that they can see how they are achieving their goals.

07

# Certificate

The Professional Master's Degree in Robotics guarantees students, in addition to the most rigorous and up-to-date education, access to a Professional Master's Degree issued by TECH Technological University.

*Successfully complete this program and receive your Postgraduate Certificate without having to travel or fill out laborious paperwork"*

This **Professional Master's Degree in Robotics** contains the most complete and up-to-date program on the market.

After the student has passed the assessments, they will receive their corresponding **Professional Master's Degree** issued by **TECH Technological University** via tracked delivery*.

The certificate issued by **TECH Technological University** will reflect the qualification obtained in the Professional Master's Degree, and meets the requirements commonly demanded by labor exchanges, competitive examinations, and professional career evaluation committees.

Title: **Professional Master's Degree in Robotics**

Official Nº of Hours: **1,500 h.**


tech technological university

Awards the following

CERTIFICATE

to

Mr./Ms. ________________, with identification number ____________.
For having successfully passed and accredited the following program

PROFESSIONAL MASTER'S DEGREE

in

Robotics

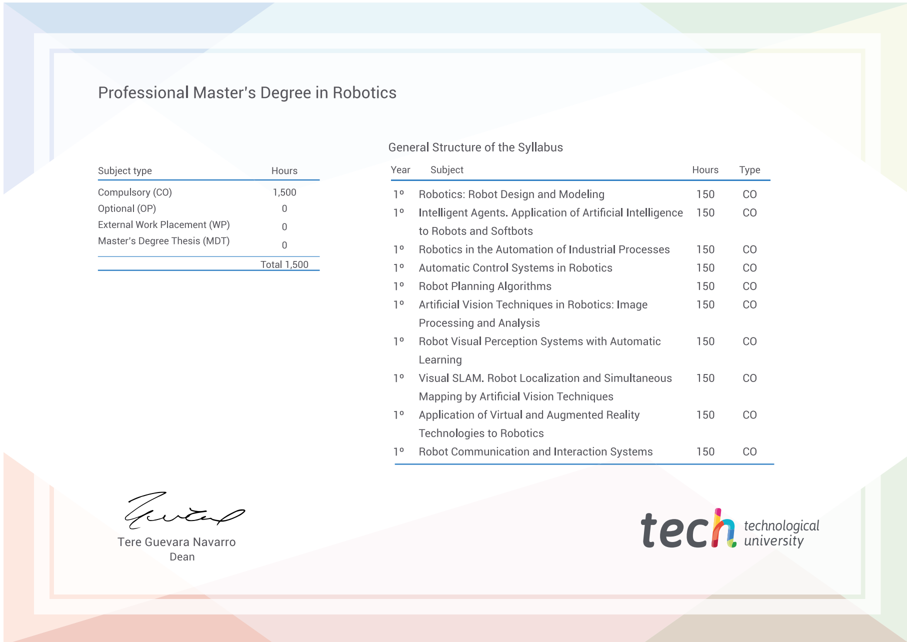
This is a qualification awarded by this University, equivalent to 1,500 hours, with a start date of dd/mm/yyyy and an end date of dd/mm/yyyy.

TECH is a Private Institution of Higher Education recognized by the Ministry of Public Education as of June 28, 2018.

June 17, 2020

Tere Guevara Navarro
Dean

This qualification must always be accompanied by the university degree issued by the competent authority to practice professionally in each country. Unique TECH Code: AFWORD23S techtitute.com/certificates


Professional Master's Degree in Robotics

| Subject type | Hours |
|---|---|
| Compulsory (CO) | 1,500 |
| Optional (OP) | 0 |
| External Work Placement (WP) | 0 |
| Master's Degree Thesis (MDT) | 0 |
| | Total 1,500 |

General Structure of the Syllabus

| Year | Subject | Hours | Type |
|---|---|---|---|
| 1º | Robotics: Robot Design and Modeling | 150 | CO |
| 1º | Intelligent Agents. Application of Artificial Intelligence to Robots and Softbots | 150 | CO |
| 1º | Robotics in the Automation of Industrial Processes | 150 | CO |
| 1º | Automatic Control Systems in Robotics | 150 | CO |
| 1º | Robot Planning Algorithms | 150 | CO |
| 1º | Artificial Vision Techniques in Robotics: Image Processing and Analysis | 150 | CO |
| 1º | Robot Visual Perception Systems with Automatic Learning | 150 | CO |
| 1º | Visual SLAM. Robot Localization and Simultaneous Mapping by Artificial Vision Techniques | 150 | CO |
| 1º | Application of Virtual and Augmented Reality Technologies to Robotics | 150 | CO |
| 1º | Robot Communication and Interaction Systems | 150 | CO |

Tere Guevara Navarro
Dean

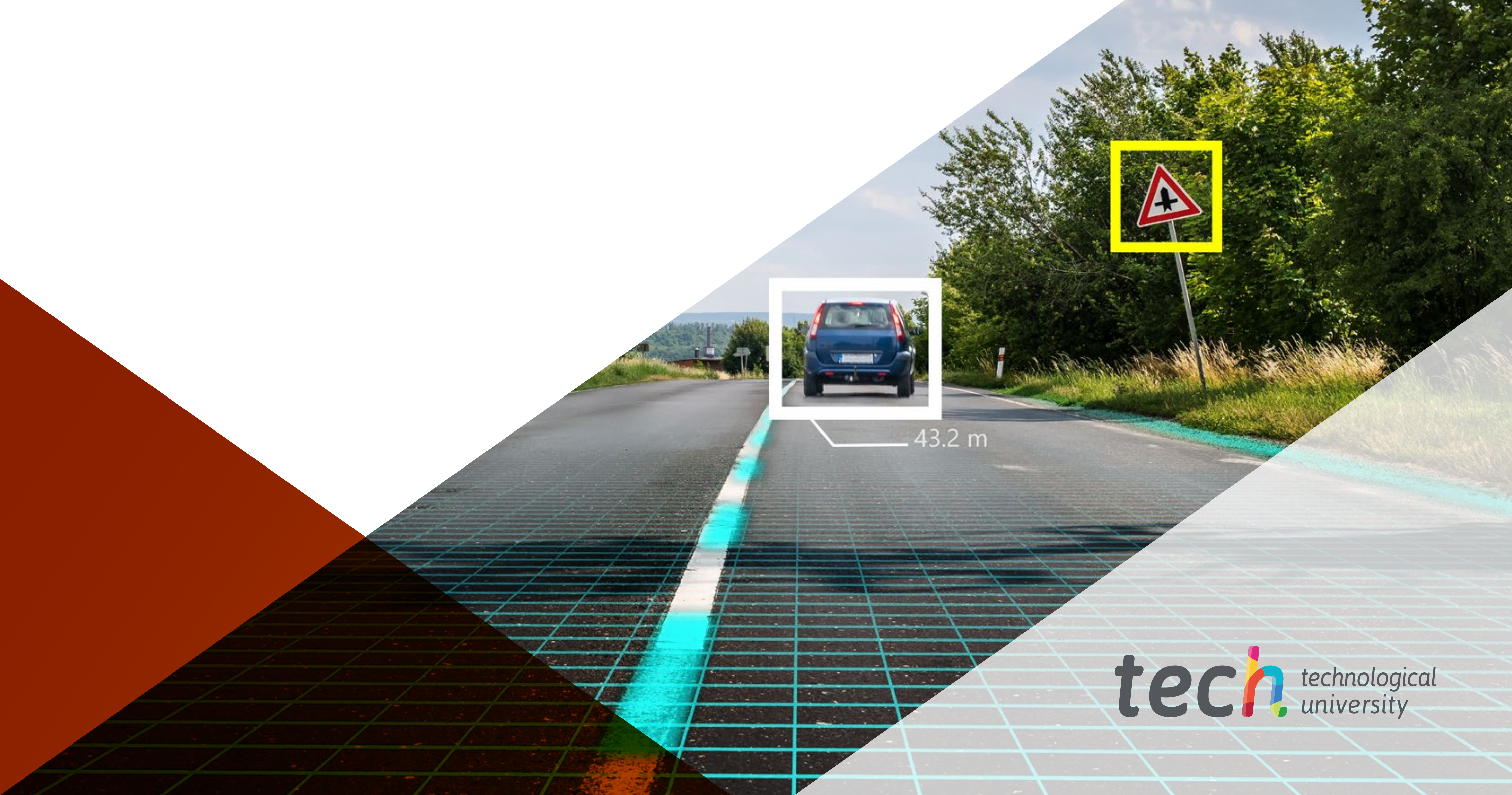
tech technological university

*Apostille Convention. In the event that the student wishes to have their paper certificate issued with an apostille, TECH EDUCATION will make the necessary arrangements to obtain it, at an additional cost.

# Professional Master's Degree
## Robotics

Course: **Online**
Duration: **12 months**
Certificate: **TECH Technological University**
Teaching Hours: **1,500 h.**

# Professional Master's Degree
## Robotics




tech technological university