Master's Degree in Control Systems Engineering

Prof. Angelo Cenedese

Control Systems Engineering in a nutshell

- total formative credit units: 120 – 126 cfu

- building on a solid base of foundational courses (24 cfu)

- offering 5 curricola covering the most active areas of control engineering;

- proposing a rich spectrum of courses;

- featuring a final project (internship+thesis) of up to 30 cfu;

- entirely taught in English;

cfu: formative credit unit – 6 cfu: 2 classes per week; 9 cfu: 3 classes per week

PROGRAMME STRUCTURE

THESIS
RESEARCH TRAINING / INTERNSHIP
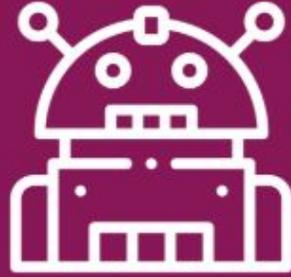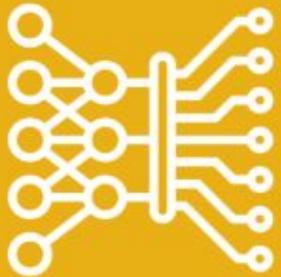
ARTIFICIAL INTELLIGENCE

ROBOTIC SYSTEMS

INDUSTRIAL AUTOMATION

SYSTEMS & CONTROL

COMPLEX SYSTEMS

FOUNDATION of COMMON COURSES:
Systems Theory - Control Lab - Estimation&Filtering

Foundation – Common mandatory activities (24+30 cfu)

Systems Theory	9 cfu	(Year 1, Semester 1)
Estimation and Filtering	6 cfu	(Year 1, Semester 2)
Control Engineering Laboratory	9 cfu	(Year 1, Semester 2)
Final Thesis	21 cfu	
Internship / Research Training	9 cfu	

Artificial Intelligence

TWO FACTS
  (1) Unprecedented quantity and/or quality of data
  (2) Modern Control Systems quest for flexibility, adaptability

Control meets **learning**

- merge physical *modeling*/insight with *data* driven methods
- exploit *data* to design *control* architectures and algorithms

MANDATORY COURSES (54 CFU)

Course	CFU	Period
Systems Theory	**9**	**Y1.S1**
Estimation and Filtering	**6**	**Y1.S2**
Control Engineering Laboratory	**9**	**Y1.S2**
Foundations of AI	9	Y1.S1
Machine Learning	9	Y1.S1
Deep Learning	6	Y1.S2
Reinforcement Learning	6	Y2.S1

ELECTIVE COURSES – AFFINE (6 CFU)

Course	CFU	Period
Convex Optimization	6	Y1.S1
Computer Vision*	6	Y1.S1
Advanced Topics in Optimization	6	Y1.S2
Learning from Networks	6	Y2.S1
Game Theory	6	Y2.S1
Natural Language Processing	6	Y2.S1
Big Data Computing	6	Y2.S2

ELECTIVE COURSES – CORE (15 CFU)

Course	CFU	Period
Digital Control	6	Y1.S1
Robotics and Control	9	Y1.S2
Adaptive and Model Predictive Control	6	Y2.S1
Industrial and Edge Machine Learning	6	Y2.S1
Mobile and Networked Robotics	9	Y2.S1
Learning Dynamical Systems	9	Y2.S1
Nonlinear Systems and Control	6	Y2.S2
Network Dynamical Systems	6	Y2.S2
Visual-Language-Action Models for Robotics	6	Y2.S2

FREE COURSES (15 CFU)

Course	CFU	Period
Any from above		
Computer Vision*	9	Y1.S2
Digital Circuits for Neural Networks	9	Y2.S2

Robotic Systems

Robots **today** are making a *considerable impact* from industrial manufacturing, to healthcare, to exploration of the deep space and sea...
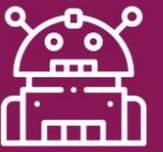…**tomorrow** they will be pervasive in our daily life
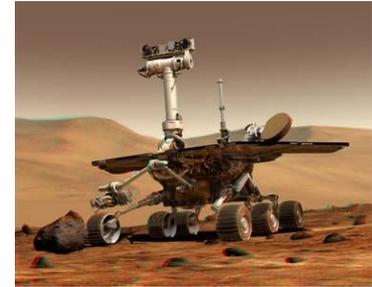
Shaping expertise *in robotics and advanced control*

- concepts of robotics, kinematic and dynamic models
- advanced control schemes for industrial and mobile robots

MANDATORY COURSES (48 CFU)

Course	CFU	Period
Systems Theory	**9**	**Y1.S1**
Estimation and Filtering	**6**	**Y1.S2**
Control Engineering Laboratory	**9**	**Y1.S2**
Digital Control	6	Y1.S1
Robotics and Control	9	Y1.S2
Mobile and Networked Robotics	9	Y2.S1

ELECTIVE COURSES – AFFINE (15 CFU)

Course	CFU	Period
Convex Optimization	6	Y1.S1
Computer Vision*	6	Y1.S1
Foundations of AI	9	Y1.S1
Advanced Topics in Optimization	6	Y1.S2
Computer Vision*	9	Y1.S2
Deep Learning	6	Y1.S2
Dynamical Systems and Lagrangian Mechanics	9	Y1.S2
Autonomous Robotics	9	Y2.S1

ELECTIVE COURSES – CORE (15 CFU)

Course	CFU	Period
Machine Learning	9	Y1.S1
Embedded Real Time Control	6	Y1.S1
Reinforcement Learning	6	Y2.S1
Adaptive and Model Predictive Control	6	Y2.S1
Industrial and Edge Machine Learning	6	Y2.S1
Industrial Robotics	9	Y2.S1
Modeling and Control of Electric Drives	9	Y2.S1
Learning Dynamical Systems	9	Y2.S1
Nonlinear Systems and Control	6	Y2.S2
Network Dynamical Systems	6	Y2.S2
Robotics Laboratory	6	Y2.S2
Design of Mechanical Drives	6	Y2.S2
Visual-Language-Action Models for Robotics	6	Y2.S2

FREE COURSES (12 CFU)

Course	CFU	Period
Any from above		

Industrial Automation

Modern Industrial Engineering is a powerful blend of
Automation – **Computer Science** – **Telecommunication**

***Challenges** and **stars** of the new Industrial Revolution*

-*Cyber-Physical Systems*: physical quantities are translated into data and information…

-*Human is in the loop*: the barrier between man and machine dissolves…

-*Resilience and autonomicity*: systems gain ability to recover from or adjust easily to misfortune or change…

MANDATORY COURSES (54 CFU)

Course	CFU	Period
Systems Theory	**9**	**Y1.S1**
Estimation and Filtering	**6**	**Y1.S2**
Control Engineering Laboratory	**9**	**Y1.S2**
Digital Control	6	Y1.S1
Embedded Real Time Control	6	Y1.S1
Industrial Automation	9	Y1.S1
Modeling and Control of Electric Drives	9	Y2.S1

ELECTIVE COURSES – AFFINE (15 CFU)

Course	CFU	Period
Convex Optimization	6	Y1.S1
Computer Vision*	6	Y1.S1
Computer Vision*	9	Y1.S2
Deep Learning	6	Y1.S2
Autonomous Robotics	9	Y2.S1
Sensing and Measurement Systems	9	Y2.S1

ELECTIVE COURSES – CORE (9 CFU)

Course	CFU	Period
Machine Learning	9	Y1.S1
Robotics and Control	9	Y1.S2
Learning Dynamical Systems	9	Y2.S1
Mobile and Networked Robotics	9	Y2.S1
Industrial Robotics	9	Y2.S1

FREE COURSES (12 CFU)

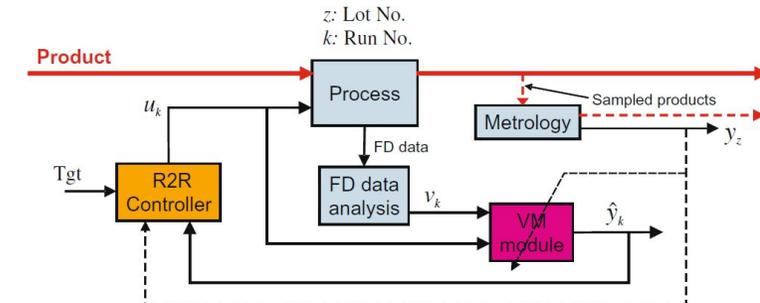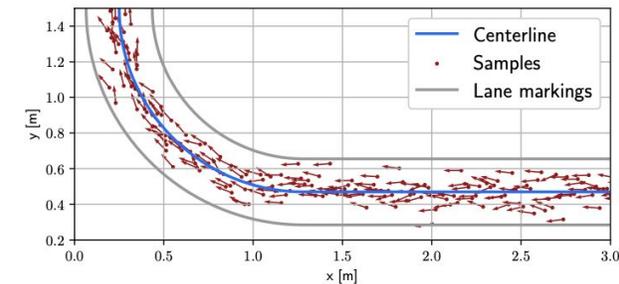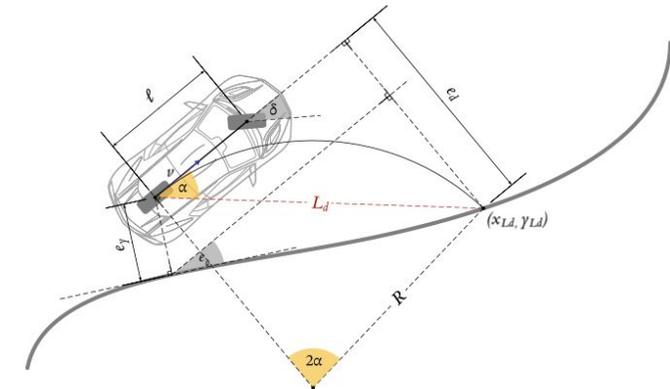| Course	CFU	Period
Any from above		
Reinforcement Learning	6	Y2.S1
Adaptive and Model Predictive Control	6	Y2.S1
Industrial and Edge Machine Learning	6	Y2.S1
Design of Mechanical Drives	6	Y2.S2

Systems and Control

Engineering Intelligence for Dynamic, Autonomous Systems,
where mathematical rigor meets
the technological challenges of the future

*Mastering **classical** and **advanced control methods**
to tackle today's challenges in industry and research*

Cutting-edge topics to prepare for innovation, by developing the analytical, computational, and methodological skills.

MANDATORY COURSES (45 CFU)

Course	CFU	Period
Systems Theory	**9**	**Y1.S1**
Estimation and Filtering	**6**	**Y1.S2**
Control Engineering Laboratory	**9**	**Y1.S2**
Convex Optimization	6	Y1.S1
Learning Dynamical Systems	9	Y2.S1
Control Pack (1 of …)		
Digital Control	6	Y1.S1
Adaptive and Model Predictive Control	6	Y2.S1
Nonlinear Systems and Control	6	Y2.S2
Network Dynamical Systems	6	Y2.S2

ELECTIVE COURSES – AFFINE (9 CFU)

Course	CFU	Period
Foundations of AI	9	Y1.S1
Computer Vision*	9	Y1.S2
Dynamical Systems and Lagrangian Mechanics	9	Y1.S2

ELECTIVE COURSES – CORE (24 CFU)

Course	CFU	Period
Any from the Control Pack		
Machine Learning	9	Y1.S1
Robotics and Control	9	Y1.S2
Reinforcement Learning	6	Y2.S1
Biomolecular Feedback Systems	6	Y2.S1
Mobile and Networked Robotics	9	Y2.S1

FREE COURSES (12 CFU)

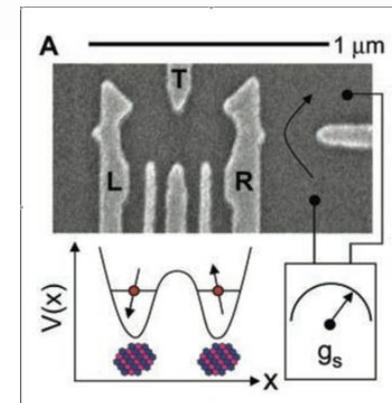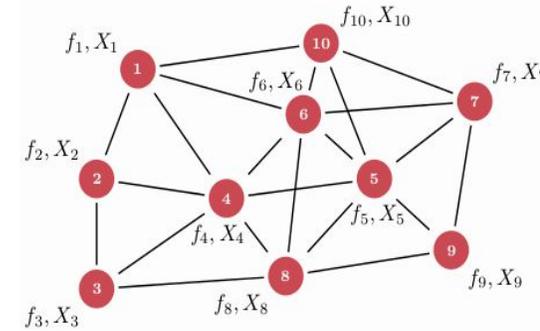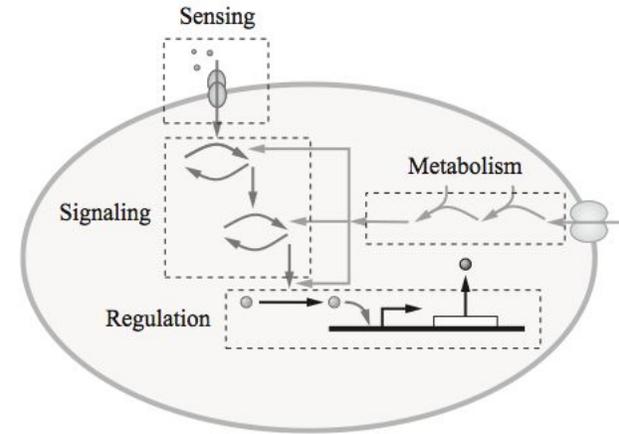| Course	CFU	Period
Any from above		
Computer Vision*	6	Y1.S1
Deep Learning	6	Y1.S2
Learning from Networks	6	Y2.S1
Game Theory	6	Y2.S1
Control of Biological Systems	6	Y2.S1

Complex Systems

Focus on tools to understand, model, control real-world systems:
Nonlinear, Networked, Biological and Quantum Systems.

*Learn how to build models from **data** and **first principles***

Oriented to concepts and methods,
naturally leads to theoretical and multidisciplinary research.

UNIVERSITÀ
DEGLI STUDI
DI PADOVA

MANDATORY COURSES (57 CFU)		
Course	CFU	Period
Systems Theory	**9**	**Y1.S1**
Estimation and Filtering	**6**	**Y1.S2**
Control Engineering Laboratory	**9**	**Y1.S2**
Machine Learning	9	Y1.S1
Dynamical Systems and Lagrangian Mechanics	9	Y1.S2
Learning Dynamical Systems	9	Y2.S1
Control Pack (1 of …)		
Nonlinear Systems and Control	6	Y2.S2
Network Dynamical Systems	6	Y2.S2

ELECTIVE COURSES – CORE (15 CFU)		
Course	CFU	Period
Any from the Control Pack		
Digital Control	6	Y1.S1
Robotics and Control	9	Y1.S2
Quantum Dynamics, Measurements and Control	6	Y1.S2
Adaptive and Model Predictive Control	6	Y2.S1
Biomolecular Feedback Systems	6	Y2.S1
Mobile and Networked Robotics	9	Y2.S1
Reinforcement Learning	6	Y2.S1

ELECTIVE COURSES – AFFINE (6 CFU)		
Course	CFU	Period
Convex Optimization	6	Y1.S1
Computer Vision	6	Y1.S1
Deep Learning	6	Y1.S2
Advanced Topics in Optimization	6	Y1.S2
Quantum Information and Computing	6	Y1.S2
Learning from Networks	6	Y2.S1
Game Theory	6	Y2.S1
Control of Biological Systems	6	Y2.S1
Big Data Computing	6	Y2.S2

FREE COURSES (12 CFU)		
Course	CFU	Period
Any from above		

Student projects are activities where groups of students, coordinated by professors, work on the design and construction of engineering systems. These projects often participate in competitions at both national and international levels. Some examples…

Alba CubeSat Unipd: the project aims to launch a CubeSat into orbit to study the space debris environment and the satellite micro-vibrations.

Race Up Team: with Formula SAE the conception, design, and production of a Formula-style car is carried out, to compete in a static and dynamic events.

BOSCH Future Mobility Challenge: Autonomous driving on 1:10 scale vehicles to navigate (and compete) in a miniature smart city.

UniZEB: multidisciplinary and permanent Living Lab on Zero Energy Buildings, with cutting-edge technologies from construction to management.

Industrial Applications Laboratory:

- Kuka robotic arm: industrial robot for man-machine collaborative action
- Conveyor belt: vision based product quality control for manufacturing
- Duckietown: cooperative mobility in a miniature smart-city
- VI-Grade Driving simulator: motion cueing & control

SPARCS Laboratory:

- Mobile robotics laboratory
- Multirotor platforms: design, simulation, estimation/perception, control, experiments

Our students found rewarding and important technical and research positions both in local and international companies in heterogeneous sectors, such as:
○ Automotive;
○ Automation and Robotics;
○ Home Appliances;
○ Power and Energy;
○ ...

Several of our fellow students are faculties/hold positions at prestigious universities around the world.
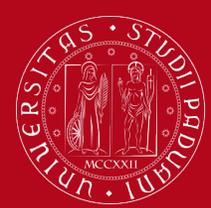
THE CONTROL GROUP

G. Baggio · L. Ballotta · A. Beghi · M. Bruschetta · R. Carli · A. Cenedese · A. Chiuso · A. Dalla Libera

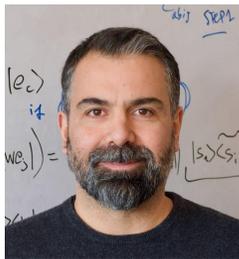P. Falco · A. Ferrante · A. Morato · M. Pezzutto · G. Pillonetto · M. Rampazzo · L. Schenato

G.A. Susto · F. Ticozzi · M.E. Valcher · D. Varagnolo · S. Vitturi · S. Zampieri · M. Zorzi