



NATIONAL PH.D. PROGRAM IN AUTONOMOUS SYSTEMS

# **Advanced control strategies with applications to sustainable bioprocesses**

## **Ph.D. candidate**

Francesco Campregher

## **Cycle**

XXXIX

## **Tutors**

Antonio Visioli

# 1. Description of the research program

The research activity deals with advanced process control strategies, such those based on PID-based complex architectures and Model Predictive Control. In addition to general applications, they will be applied to microalgae bioreactors. In fact, water pollution and global warming are two big issues that are affecting our society and microalgae provides an appealing solution that can address these two problems in an efficient way. Thanks to their ability to purify the water through their reproduction and their photosynthetic process. This study relies on the facilities located at the University of Almería, Spain, where there is a physical bioreactor: Raceway.

To make this an actual solution, important challenges must be addressed such as economic feasibility and optimal growth rate. The model is highly nonlinear and dependent on atmospheric agent, first of all the sun light; in addition, observation techniques will be explored, such as Kalman filter. In order to give an answer to this problem, different possible solutions will be investigated in a hierarchal structure, which allow the consideration of the overall control problem.

The PhD thesis will be developed in the Control System Group at the University of Brescia in collaboration with the Automatic Control, Robotics and Mechatronics research group of the University of Almería, Spain.

# 2. Schedule of the research activities

## First academic year (planned)

	Description	Period	Activity abroad
<b>Bibliographic research</b>	Keeping up with the state of the art about process control and identification techniques. In particular, models and current control solutions for microalgae will be studied.	11/2023-04/2024	NO
<b>Studying about the prediction models</b>	Definition of different plant models.	05/2024-06/2024	NO
<b>Estimators design</b>	Design of the estimation algorithms adopted to evaluate the models.	07/2024-09/2024	NO
<b>Simulation</b>	Simulation of the models based on previous collected data	10/2024	NO

## Second academic year (planned)

	Description	Period	Activity abroad
<b>Simulation</b>	Simulation of the models based on previous collected data	11/2024	NO
<b>Experimental Validation</b>	Validation of the models on the real plant	12/2024-02/2025	YES the plant is located at the University of Almeria, Spain
<b>Advanced control system definition</b>	Study and formulation of advanced control strategies	12/2024-04/2025	NO
<b>Simulation</b>	Simulation of the control strategies developed	05/2025-06/2025	NO
<b>Experimental Application</b>	Test of the control strategies on real plants	07/2025-09/2025	YES the plant is located at the

			University of Almeria, Spain
<b>Economic advance control strategies</b>	Study and development of advanced control strategies that take into account also the economic aspect of the problem, such as HMPC and reinforcement learning	07/2025-10/2025	NO

### Third academic year (planned)

	Description	Period	Activity abroad
<b>Economic advance control strategies</b>	Study and development of advanced control strategies that take into account also the economic aspect of the problem, such as HMPC and reinforcement learning	11/2025	NO
<b>Simulation</b>	Simulation of the entire system	12/2025-01/2026	NO
<b>Analysis of robustness</b>	Analysis of robustness of the different control strategies	02/2026-03/2026	NO
<b>Comparison between the two approaches</b>	Comparison of the different control strategies	04/2026-05/2026	NO
<b>Thesis writing</b>		06/2026-10/2026	NO

## 3. Training and research activities plan

### First academic year (planned)

	Description	Period	Final Exam	ECTS
<b>A. Ph.D. courses</b>	From Least Squares to Subspace Identification	02/2024-03/2024	Yes	2
	Intelligent Control Systems	01/2024-02/2024	Yes	2
<b>B. Master's degree courses</b>	Optimization Algorithms	09/2024-12/2024	Yes	6
	7 <sup>th</sup> spring school data-driven Model Learning of Dynamic Systems	08/04/2024-12/04/2024	No	5
	Scuola di dottorato SIDRA	07/2024	No	5
<b>C. Soft skill courses</b>				
<b>D. Participation to seminars</b>				
<b>E. Participation to international congresses or workshops</b>	IFAC conference on advances on PID control	12/06/2024-14/06/2024	No	3
<b>F. Presentation of research products at international congresses or workshops</b>	IFAC conference on advances on PID control	12/06/2024-14/06/2024	No	1
<b>TOTAL OF ECTS FOR TRAINING ACTIVITIES</b>				<b>25</b>

<b>G. Individual research activity</b>				25
<b>H. Supervision of students</b>	Application and development of observer and advance control strategies for simulated nonlinear systems			4
<b>I. Integrative teaching activities</b>				1
<b>J. Preparation of manuscripts for conferences or journals</b>				5
<b>TOTAL OF ECTS FOR RESEARCH ACTIVITIES</b>				35
<b>TOTAL OF ECTS</b>				<b>60</b>

### Second academic year (planned)

	Description	Period	Final Exam	ECTS
<b>A. Ph.D. courses</b>				
<b>B. Master's degree courses</b>				
<b>C. Soft skill courses</b>				
<b>D. Participation to seminars</b>				
<b>E. Participation to international congresses or workshops</b>				
<b>F. Presentation of research products at international congresses or workshops</b>				
<b>TOTAL OF ECTS FOR TRAINING ACTIVITIES</b>				20
<b>G. Individual research activity</b>				30
<b>H. Supervision of students</b>				4
<b>I. Integrative teaching activities</b>				1
<b>J. Preparation of manuscripts for conferences or journals</b>				5
<b>TOTAL OF ECTS FOR RESEARCH ACTIVITIES</b>				40
<b>TOTAL OF ECTS</b>				<b>60</b>

### Third academic year (planned)

	Description	Period	Final Exam	ECTS
<b>A. Ph.D. courses</b>				
<b>B. Master's degree courses</b>				

<b>C. Soft skill courses</b>				
<b>D. Participation to seminars</b>				
<b>E. Participation to international congresses or workshops</b>				
<b>F. Presentation of research products at international congresses or workshops</b>				
	<b>TOTAL OF ECTS FOR TRAINING ACTIVITIES</b>			<b>5</b>
<b>G. Individual research activity</b>				<b>45</b>
<b>H. Supervision of students</b>				<b>4</b>
<b>I. Integrative teaching activities</b>				<b>1</b>
<b>J. Preparation of manuscripts for conferences or journals</b>				<b>5</b>
	<b>TOTAL OF ECTS FOR RESEARCH ACTIVITIES</b>			<b>55</b>
	<b>TOTAL OF ECTS</b>			<b>60</b>

#### 4. List of the publications written by the candidate in the triennium

Francesco Campregher



Antonio Visioli

