



NATIONAL PH.D. PROGRAM IN AUTONOMOUS SYSTEMS

Tecniche di AI/Machine Learning per applicazioni in ambito satellitare/spaziale

Ph.D. candidate

Kirolos Romany Anwar Kamel

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Tutors

Francesco Delli Priscoli

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1. Description of the research program

My PhD program, a collaborative effort between Sapienza University of Rome and Telespazio, focuses on developing innovative solutions that combine satellite technology and intelligent control techniques to enhance the autonomy and reliability of systems, and improve their overall efficiency. My research aims to address critical challenges in both aerospace and underwater domains. My primary research goal is to continue my master's thesis work and develop an open-source digital twin framework for precise positioning and navigation of underwater vehicles, specifically Remotely Operated Vehicles (ROVs). This framework will simulate real-world underwater conditions, enabling ROVs to autonomously and efficiently perform tasks such as inspection, maintenance, and repair of critical underwater infrastructure. By contributing to this field, I aim to enhance the reliability of these essential robot systems. To initiate my research, I will enhance an existing digital replica of a chosen ROV model. By accurately estimating the model parameters, this refined digital replica will meticulously describe the vehicle's physical properties. Next, I will develop a sensing system to extract simulated vehicle information, including position and speed. Finally, I will integrate an intelligent control technique based on passivity concepts, specifically designed for fully actuated ROVs. Finally, all these models will be integrated into a simulated underwater environment using a real-time simulator like Unreal Engine. This comprehensive simulation framework will allow for rigorous testing and validation of the ROV's autonomous capabilities in various scenarios. My secondary research goal is to develop a deep reinforcement learning control system that combines satellite imagery and real-time sensor data from a network of sensors to predict wildfires. This integrated approach allows proactively to identify potential fire risks, optimize resource allocation, and implement timely interventions to mitigate the impact of wildfires. I will begin by enhancing an existing fire prediction model to improve its performance.

2. Schedule of the research activities

First academic year (planned)

	Description	Period	Activity abroad
<i>Digital Twin Technology with Integrated Satellite Data for Enhanced AUVs Inspection and Intervention Capabilities.</i>	This project focuses on a critical technology for Remotely Operated Vehicles (ROVs): a digital twin. This revolutionary technology allows us to test ROVs operations in simulated scenarios before real-world missions.	First-second semester. Work will also be done at Telespazio company starting from January	NO
<i>Advanced multi-rat integrated multi-sensors solution for emergency prevention, detection and response operations</i>	Starting with the pressing issue of wildfires, the goal is to develop a cutting-edge deep reinforcement learning system that leverages the power of satellite imagery and real-time sensor data to accurately predict and mitigate these destructive events. By integrating these diverse data sources, we aim to create a robust and adaptive control system capable of proactively predicting wildfires.	First-second semester Held also in Telespazio	NO

Second academic year (planned)

	Description	Period	Activity abroad
<i>Digital Twin Technology with Integrated Satellite Data for Enhanced AUVs Inspection and Intervention Capabilities.</i>	This project focuses on a critical technology for Remotely Operated Vehicles (ROVs): a digital twin. This revolutionary technology allows us to test ROVs operations in simulated scenarios before real-world missions.	First-second semester Held also in Telespazio	No
<i>Advanced multi-rat integrated multi-sensors solution for emergency prevention, detection and response operations</i>	Starting with the pressing issue of wildfires, the goal is to develop a cutting-edge deep reinforcement learning system that leverages the power of satellite imagery and real-time sensor data to accurately predict and mitigate these destructive events. By integrating these diverse data sources, we aim to create a robust and adaptive control system capable of proactively predicting wildfires.	Second semester 01/07/2026 – 31/12/2026	YES Where: TBD

Third academic year (planned)

	Description	Period	Activity abroad
<i>Digital Twin Technology with Integrated Satellite Data for Enhanced ROVs Inspection and Intervention Capabilities.</i>	This project focuses on a critical technology for Remotely Operated Vehicles (ROVs): a digital twin. This revolutionary technology allows us to test ROVs operations in simulated scenarios before real-world missions.	First-second semester	NO
<i>Advanced multi-rat integrated multi-sensors solution for emergency</i>	Starting with the pressing issue of wildfires, the goal is to develop a cutting-edge deep reinforcement learning system that leverages the power of satellite imagery and real-time sensor data to accurately predict and mitigate	First-second semester	NO

<i>prevention, detection and response operations</i>	these destructive events. By integrating these diverse data sources, we aim to create a robust and adaptive control system capable of proactively predicting wildfires.		
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3. Training and research activities plan

First academic year (planned)

	Description	Period	Final Exam	ECTS
A. Ph.D. courses	Simulation Systems for Engineering Applications	May	Yes	1
	Distributed/Decentralized Control and Optimization of Large-Scale Systems	January-February	Yes	1
	Simulation, optimization, and management of smart energy systems	September	Yes	1
B. Master's degree courses	Vehicle system dynamics	First semester	No	3
	Reinforcement learning	Second semester	Yes	6
C. Soft skill courses				
D. Participation to seminars				
E. Participation to international congresses or workshops	Participation to six-day international congress of workshop according to availability, and/or SIDRA Doctoral school	January-December		6
F. Presentation of research products at international congresses or workshops				
	TOTAL OF ECTS FOR TRAINING ACTIVITIES			18
G. Individual research activity	The development of digital twins for underwater vehicles	First-second semester	November 2024 - August 2025	21
	Wildfire model prediction enhancement and validation.	First-second semester	November 2024 - August 2025	21
H. Supervision of students				
I. Integrative teaching activities				
J. Preparation of manuscripts for conferences or journals				
	TOTAL OF ECTS FOR RESEARCH ACTIVITIES			42
	TOTAL OF ECTS			60

Second academic year (planned)

	Description	Period	Final Exam	ECTS
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A. Ph.D. courses	Learning in multi-agent systems		Yes	2
	Human Autonomous System Interaction		Yes	1
B. Master's degree courses	Machine learning for signal processing	Second semester	YES	6
C. Soft skill courses				
D. Participation to seminars	2-3 Dausy seminars	TBD	NO	6
E. Participation to international congresses or workshops	EECI International Graduate School on Control: Dissipativity in Optimal Control - Turnpikes, Predictive Control, and Uncertainty	12/05-16/05	Yes	3
F. Presentation of research products at international congresses or workshops	Presentation of manuscript	TBD		5
TOTAL OF ECTS FOR TRAINING ACTIVITIES				23
G. Individual research activity	Starting the second phase of The development of digital twins for underwater vehicles, by working on the simulation of the underwater environment using the Unreal Engine	First-second semester		27
H. Supervision of students	Supervision of student's bachelor thesis on Automatic Control	First-second semester		5
I. Integrative teaching activities	Control of autonomous multi-agent systems seminars	Second semester		5
J. Preparation of manuscripts for conferences or journals				
TOTAL OF ECTS FOR RESEARCH ACTIVITIES				37
TOTAL OF ECTS				60

Third academic year (planned)

	Description	Period	Final Exam	ECTS
A. Ph.D. courses				
B. Master's degree courses				
C. Soft skill courses				
D. Participation to seminars				
E. Participation to international congresses or workshops				
F. Presentation of research products at international congresses or workshops				
TOTAL OF ECTS FOR TRAINING ACTIVITIES				
G. Individual research activity	New Intelligent control algorithm development for accurate positioning and navigation of underwater vehicles	2026/2027		35

H. Supervision of students	Supervision of student's bachelor thesis	2026/2027		5
I. Integrative teaching activities	Seminars of Control of autonomous multi-agent systems seminars	2026/2027		5
J. Preparation of manuscripts for conferences or journals	Preparation of manuscript	2026/2027		15
TOTAL OF ECTS FOR RESEARCH ACTIVITIES				
TOTAL OF ECTS				60

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