**Attachment 8**

**PhD PROGRAMME IN NATIONAL RESEARCH FOR AUTONOMOUS SYSTEMS**

PhD Programme in collaboration with: *Centro Nazionale delle Ricerche (CNR National Research Centre), Politecnico di Torino, Scuola IMT Alti Studi Lucca, Università del Salento, Università del Sannio, Università dell'Aquila, Università della Calabria – Rende, Università della Campania L. Vanvitelli, Università di Bologna, Università di Cagliari, Università di Firenze, Università di Genova, Università di Modena e Reggio Emilia, Università di Padova, Università di Palermo, Università di Parma, Università di Pisa, Università di Roma Tor Vergata, Università di Roma Tre, Università di Salerno, Università di Siena, Università di Trento, Università di Verona, Università Politecnica delle Marche.*

Administrative Centre: *Politecnico di Bari*

*Project Identification Code (CUP): D93C22000500001; D93C22000580001; D93D22001390001*

| **XXXVIII CYCLE DOCTORATE PROGRAMME PROFILE** | |
|---|---|
| **DEPARTMENT** | Department of Electrical and IT Engineering |
| **COORDINATOR** | Prof. Mariagrazia Dotoli (mariagrazia.dotoli@poliba.it) |
| **PLACES AVAILABLE** | 35 |
| of which | |
| *Places with grants **awarded by university / fund of participating institution*** <br><br> ***Refer to research topic list below*** | 5 <br> of which: <br><br> GRANT N. 1 - Politecnico di Bari – **Topic**: *"Decision and control techniques for intelligent diagnosis and surgery using digital twins";* <br><br> GRANT N. 2 – National Research Centre – **Topic:** "*Advanced learning and control methods with life science applications*"; <br><br> GRANT N. 3 - Università di Roma Tre; **Topic: "***A model based security and monitoring system for resilient industrial control systems";* <br><br> GRANT N. 4 - Università di Salerno – **Topic:** "*Performance-aware and resilient supervisory control of cyber-physical and industrial automation systems*"; <br><br> GRANT N. 5 - Università di Siena – **Topic:** *"Awareness in human-human and human-robot interactions*". |
| *Places with grant funded by NRRP – as per Ministerial Decree **351/2022*** <br><br> ***Refer to research topic list below*** | 19 <br> of which: <br><br> GRANT N. 6 - Politecnico di Bari – **Area**: Public Administration; **Topic:** *"Decision and control techniques for energy management of smart cities";* <br><br> GRANT N. 7 - Politecnico di Bari – **Area**: NRRP; **Topic:** *"Smart control systems for rural energy communities ";* <br><br> GRANT N. 8 - Politecnico di Torino - **Area**: Public Administration; **Topic:** *"Learning and control of complex networks and financial systems";* |

| | |
|---|---|
| | GRANT N. 9 - Scuola IMT Alti Studi Lucca – **Area:** NRRP; **Topic** "*Machine learning paradigms for fast and faithful approximations of model predictive controllers*";<br><br>GRANT N. 10 - Università del Salento – **Area:** NRRP; **Topic:** "*Model-based and data-driven learning and control of complex network systems*";<br><br>GRANT N. 11 - Università del Sannio - **Area:** NRRP; **Topic** "*Emergent behaviours in opinion dynamics*";<br><br>GRANT N. 12 - Università della Calabria Rende - **Area:** NRRP; **Topic:** "*Control strategies for energy harvesting systems*";<br><br>GRANT N. 13 - Università della Campania "L. Vanvitelli" - **Area:** NRRP; **Topic:** "*Supervision and control techniques for energy management in More Electric Aircraft*";<br><br>GRANT N. 14 - Università di Cagliari - **Area:** Public Administration; **Topic:** *"Fault diagnosis and security in smart cities";*<br><br>GRANT N. 15 - Università di Firenze - **Area:** NRRP; **Topic:** *"Distributed multi-object estimation for cooperative autonomous systems*";<br><br>GRANT N. 16 - Università di Genova - **Area:** NRRP; **Topic:** "*Robust control of traffic networks with heterogenous vehicles*";<br><br>GRANT N. 17 - Università di Modena e Reggio Emilia - **Area:** NRRP; **Topic:** "*Exploiting predictive capabilities in motion control for autonomous vehicles operating in crowded environments*";<br><br>GRANT N. 18 - Università di Padova - **Area:** NRRP; **Topic:** "*Advanced modeling and control of complex systems*";<br><br>GRANT N. 19 - Università di Palermo - **Area:** Public Administration; **Topic:** "*Sensor network and data analysis to support decision and governance of complex systems";*<br><br>GRANT N. 20 - Università di Pisa - **Area:** Public Administration; **Topic:** "*Artificial intelligence in autonomous robotic service fleet management for smart cities of the future ";*<br><br>GRANT N. 21 - Università di Roma Tor Vergata - **Area:** NRRP; **Topic:** "*Advanced control allocation techniques for large multi-agent systems and large sensor/actuator networks*";<br><br>GRANT N. 22 - Università di Trento - **Area:** NRRP; **Topic:** "*A mathematical theory for control and optimization of evolutionary phenomena*";<br><br>GRANT N. 23 - Università di Trento - **Area:** Digital and Environmental Transition; **Topic:** "A *shared-control framework for smart human-vehicle cooperation in the context of autonomous and assisted driving*";<br><br>GRANT N. 24 - Università Politecnica delle Marche - **Area:** NRRP; **Topic:** "*A model-based design for increasing reliability and safety of autonomous systems*". |

| | |
|---|---|
| *Places with grant funded by NRRP – as per Ministerial Decree* ***352/2022***<br><br>***<u>Refer to research topic list below</u>*** | 11<br>of which:<br><br>GRANT N. 25 - Politecnico di Bari - **Co-funded by**: ICAM s.r.l.; **Topic: "***Decision and control techniques for collaborative robotics in automated warehouses";*<br><br>GRANT N. 26 - Politecnico di Bari - **Co-funded by**: ICAM s.r.l.; **Topic: "***Decision and control techniques for fleets of cooperative robots in automated warehouses";*<br><br>GRANT N. 27 - Università dell'Aquila - **Co-funded by**: BluHub s.r.l..; **Topic:** *"Control, coordination and monitoring of autonomous agents, with application to the agri-food field";*<br><br>GRANT N. 28 - Università di Bologna – **Co-funded by**: STAM s.r.l. - **Topic:** "*Development of solutions for mobile and collaborative robotics in complex environments";*<br><br>GRANT N. 29 - Università di Bologna – **Co-funded by**: Thales Alenia Space Italia s.p.a. - **Topic:** *"Artificial intelligence and control tools for cognitive satellite SAR systems";*<br><br>GRANT N. 30 – Università di Genova – **Co-funded by:** Circle s.p.a. – **Topic: "***Monitoring and optimally managing movement of goods on multimodal networks";*<br><br>GRANT N. 31 - Università di Modena e Reggio Emilia - **Co-funded by**: IVECO DV&Astra - **Topic:** *"Motion planning, control and coordination of off-road autonomous mining trucks";*<br><br>GRANT N. 32 - Università di Parma - **Co-funded by**: GSK Manufacturing s.p.a. - **Topic:** *"Predictive maintenance, fault and anomaly detection for chemical and pharmaceutical processes";*<br><br>GRANT N. 33 - Università di Verona - **Co-funded by**: Mafin s.r.l. - **Topic:** *"Causal representation learning for time series monitoring in continuous food manufacturing processes";*<br><br>GRANT N. 34 - Università Politecnica delle Marche - **Co-funded by**: CNH Industrial Italia s.p.a. - **Topic:** *"Predictive maintenance and anomaly detection for agricultural tractor components";*<br><br>GRANT N. 35 - Università Politecnica delle Marche - **Co-funded by**: Schnell s.p.a. - **Topic:** *"Self-diagnosis and total fault prediction solutions based on data and signals in autonomous machines for structural steel processing".* |
| **ADMISSION REQUIREMENTS**<br>*Applicants to the PhD programme in Autonomous Systems Research* ***must hold a second level (specialized) degree*** | ➢ Degree diploma awarded by the Italian university system prior to Ministerial Decree 509/99;<br>➢ Specialist Degree (as per Ministerial Decree 509/99);<br>➢ Master's Degree (as per Ministerial Decree 270/04);<br>➢ Degree qualifications awarded by foreign universities officially recognised as equivalent[1]. |

[1] *Where a qualification awarded by a foreign university* ***has not yet been declared equivalent*** *to an Italian university degree, subject to verification by the administration offices, the Selection Committee will decide upon the eligibility of the foreign qualification in line*

| | |
|---|---|
| **COURSE PROGRAMMES**<br>*(successful candidates to select from this list at time of enrolment)* | ➢ **Programme 1 - AS for automation**<br>In order to achieve sustainable and green automation, doctorate students study topics aimed towards the automation of industrial systems of the future and rendering these high-performance. This includes distributed control and supervision of sensor and actuator networks, collaborative robotics, advanced modeling methodology, optimization and simulation of digital twin techniques, the use and study of modern, advanced mathematical tools and theories. Fields of application: Programme 1 covers all areas of automation, not only for production processes, but also in agriculture and transport & logistics. Keywords: automation in manufacturing, collaborative robotics, industry 4.0, digital twin, sensor-actuator networks, simulation and optimization, supervisory control, sustainability and green automation. For this and all other programmes there will be a minimum of 6 teaching staff members with a scientific profile directly related to the programme fields. Moreover, at least two grant-funded positions will be made available.<br><br>➢ **Programme 2 - AS for smart environments**<br>In intelligent environments such as smart cities, autonomous vehicles and mobile robots, smart grids, sustainable mobility systems, smart buildings and intelligent homes, in-depth study is vital on advanced control topics based on cyber-physical systems and distributed optimization which apply predictive control methodologies and consensus, training or control algorithms on networks and system-distributed identification. One current example is that of the sustainable development of power systems which requires new approaches to manage and control renewable sources and energy storing systems. These are no longer centralised but distributed and benefit from the implementation of the topics addressed in this programme. Fields of application: Programme 2 covers interconnecting systems and smart technology (smart grids, smart cities, smart buildings, autonomous vehicles, etc.). There is also focus on the monitoring of public administration environmental systems and networks (air quality in public environments and schools, public lighting systems, etc.). Keywords: autonomous vehicles, cyber-physical systems, consensus, distributed optimization, formation control, mobile robotics, networked control, smart grids, smart cities. For this and all other programmes there will be a minimum of 6 teaching staff members with a scientific profile directly related to the programme fields. Moreover, at least two grant-funded positions will be made available.<br><br>➢ **Curriculum 3 - AS for monitoring and security**<br>A key difficulty in planning and managing autonomous systems is in guaranteeing their reliability and security. This requires ensuring their correct operation, also in situations of uncertainty (resilience), monitoring and predicting malfunctions, guaranteeing compliance with confidentiality and privacy requirements, preventing physical and cyber-attacks, and planning safe processes in environments which |

*with current Italian regulations and those of the country of origin, as well as any international treaties or agreements on qualification recognition for further study.*

| | |
|---|---|
| | feature interaction between automated systems and humans. Fields of application: as underlined in many of the NRRP missions, the word *safety* features in numerous fields, such as the environment, IT, public administration, buildings, networks, medical clinics, etc. Keywords: brain-computer interaction, cyber-attacks, cybersecurity, fault diagnosis, fault prognosis, human in the loop, human-robot interaction, opacity, robotic surgery, safety of processes. For this and all other programmes there will be a minimum of 6 teaching staff members with a scientific profile directly related to the programme fields. Moreover, at least two grant-funded positions will be made available. |

| **APPLICATION PROCEDURES** | |
|---|---|
| Please note that the information provided below complements and does not substitute that contained in arts. 2 and 3 of the general Application Call.<br><br>**N:B: Candidates must state, in order of priority, 5 research grant preferences (from the programme profile section above) in the section outlining candidate research proposals (“*ALLEGATO H_FORMAT PROPOSTA DI RICERCA_DAUSY*”) available at the following link: https://www.poliba.it/sites/default/files/dottorati/allegato_h_format_proposta_di_ricerca_dausy_0.docx.** | |
| **REQUIRED DOCUMENTATION**<br>*Candidates must upload the following documentation to their online application.* ***Failure to do so will result in their exclusion from the selection procedure.*** | ➢ **A CV** following the layout of the example provided by Politecnico di Bari at https://www.poliba.it/it/dottorati-di-ricerca.<br><br>*(File to be named “01.CV”).*<br><br>➢ **Copy of a current identification document**. Only the following documents will be considered eligible:<br>• ID cards issued by an EU member state;<br>• driving licence issued by an EU member;<br>• in all other cases, a full validity passport (also non-EU citizens).<br><br>*(File to be named “02.Documento Riconoscimento”).*<br><br>➢ **Degree qualification certification for first (Bachelor’s) degrees and second (specialization/Master’s) degrees (or 5-year Single Cycle degrees)**.<br><br>**Candidates with qualifications awarded in Italy** must attach the Politecnico form available at https://www.poliba.it/it/dottorati-di-ricerca, specifying:<br>• final degree mark;<br>• a list of all exams taken with their relative marks in both degree courses (or the Single Cycle course);<br>• results of exams taken.<br><br>*(File to be named “03.Titoli di Laurea”).*<br><br>**Candidates with a degree qualification awarded by a non-Italian university** must attach the following documents to their |

application, as issued by the awarding body. This supersedes any form of self-declaration [2]:

- Degree certificate or diploma showing relative final mark;
- Official transcript of exams taken during all university study programmes, showing relative results;
- Any other type of document which demonstrates the equivalence of qualifications with those required in this application call (Supplementary Diploma, *Dichiarazione di Valore* (statement of value) issued locally.

*(File to be named "03.Titoli di Laurea")*.

- **An abstract of the thesis topic for specialist/Master's degree (or five-year Single Cycle degree),** stating the title and name of thesis supervisor(s) (max 3,000 characters).

  *(File to be named "04.Abstract Tesi")*.

- **Candidate thesis for specialist/Master's degree (or five-year Single Cycle degree)**

  For **graduating students** whose thesis is not yet complete (see art.2), a draft version of the thesis which has been completed up to the time of application; (**N.B.** "draft version" implies a version of the thesis text as completed by the graduating candidate up to the date of application, which, in terms of chapters and pages, allows the Selection Committee to evaluate its relative content and subject area. The abstract is uploaded as a separate file and is not considered as a draft version of the thesis under any circumstances.

  *(File to be named "05.Tesi")*..

- **PhD research** proposal which the candidate intends to develop during the programme, stating the scientific basis of the proposal, its research objectives and the methods to be used. Research proposals and projects are assessed purely for the purposes of admission and are not necessarily those which the candidate will follow during the programme.

  **Research proposals must use the format available at the following link (title *"ALLEGATO H_FORMAT PROPOSTA DI RICERCA_DAUSY"*): https://www.poliba.it/sites/default/files/dottorati/allegato_h_format_proposta_di_ricerca_dausy_0.docx).**

  **N.B**: Candidates who intend to propose a research project based on the topics set out in Ministerial Decrees 351/2022 and 352/2022 must prepare a proposal in line with one or more of the topics listed below.

[2] **N.B.**: These documents must be in Italian, French or English or translated into Italian or English and verified by an official Italian diplomatic or consular representative under the responsibility of the candidate. These should follow the guidelines set out in the document "*PROCEDURES FOR ENTRY, RESIDENCY AND ENROLMENT OF INTERNATIONAL STUDENTS AND THE RESPECTIVE RECOGNITION OF QUALIFICATIONS, FOR HIGHER EDUCATION COURSES IN ITALY FOR THE ACADEMIC YEAR 2022/23*" available at the Ministry link https://www.studiare-in-italia.it/studentistranieri/".

| | |
|---|---|
| | *(File to be named "06.Proposta Ricerca").* |
| **OPTIONAL DOCUMENTATION** | ➢ **A self-certification declaration for any other qualifications** deemed suitable for evaluation which must be signed and dated (following the layout of the example provided at https://www.poliba.it/it/dottorati-di-ricerca), as per arts.46 and 47 of Presidential Decree n. 445/2000.<br><br>*(File to be named "07.Dichiarazione altri titoli"*).<br><br>➢ **Either one or two letters of reference from teaching staff** who have supervised the candidate throughout their university-level studies.<br><br>*(Files to be named "08.Lettera presentazione 1", "08. Lettera presentazione 2"*).<br><br>➢ **Language certification** demonstrating a knowledge of English which corresponds to at least B2 level. Only those candidates who are non-Italian citizens may attach certification which demonstrates knowledge of the Italian language.<br><br>*(File to be named "09.Certificazione linguistica 1"; etc*).<br><br>➢ **Any publications** related to activity carried out and shown on the candidate's CV. These must be in either Italian or English or translated into Italian or English on behalf of and under the responsibility of the candidate.<br><br>In cases of **large publications** unavailable in electronic format or which exceed the number of MB permitted for documents, applicants may submit these separately (in paper format or as a CD or DVD-ROM), together with a detailed explanatory list, by 2 p.m. on the deadline date for applications.<br><br>All publications submitted on paper or on electronic media must be sent in a sealed envelope, signed along the flap, to the following address: Magnifico Rettore del Politecnico di Bari – Direzione Gestione Risorse e Servizi Istituzionali - Settore Ricerca, Relazioni Internazionali e Post-Lauream - Ufficio Protocollo – Via Amendola 126/B, 70126 BARI (Italy). Envelopes must show the name and surname of the candidate together with the following text: "*Concorso di Ammissione al Corso di Dottorato in…* (name of the PhD programme)". The delivery of the envelope containing publications to Politecnico di Bari – by postal service, private courier or shipping agency – is wholly at the candidate's risk.<br><br>*(File to be named "10.Pubblicazione 1"; etc*). |
| **DOCUMENT CHECKLIST** | **Required documentation:**<br><br>➢ **CV** *(to be named "01.CV"*);<br><br>➢ **Copy of a current identification document** *(to be named "02.Documento Riconoscimento"*); |

| | |
|---|---|
| | ➢ **Degree qualification certification for first (Bachelor's) degrees and second (specialization/Master's) degrees (or 5-year Single Cycle degrees)** *(to be named "03.Titoli di Laurea"*);<br>➢ **Abstract of the thesis topic for specialist/Master's degree (or five-year Single Cycle degree)** *(to be named "04.Abstract Tesi"*);<br>➢ **Candidate thesis for specialist/Master's degree (or five-year Single Cycle degree)** *(to be named "05.Tesi"*);<br>➢ **PhD research proposal** (*to be named "06.Proposta di Ricerca").*<br><br>**<u>Optional documentation:</u>**<br>➢ **Self-certification declaration for any other qualifications** *(to be named "07.Dichiarazione altri titoli"*);<br>➢ **Either one or two letters of reference from teaching staff** *(to be named "08.Lettera presentazione 1", "08. Lettera presentazione 2"*);<br>➢ **Language certification** *(to be named "09.Certificazione linguistica 1"; etc*);<br>➢ **Any publications** *(to be named "10.Pubblicazione 1"; etc).* |

| **ADMISSION EXAMINATION** | |
|---|---|
| **1.ASSESSMENT OF QUALIFICATIONS HELD** | Assessment of qualifications held (average exam scores, final degree mark, theses, Master's degrees, post-graduate courses, language certification, publications, etc.). |
| **2. ASSESSMENT OF RESEARCH PROPOSAL** | |
| **3. INTERVIEW** | The interview provides an opportunity for a complete evaluation of the candidate and a verification of the applicant's aptitude for research and willingness to undertake experience abroad, as well as areas of research interest |
| **DATES OF INTERVIEWS** | Monday 12 Sept 2022;<br>Tuesday 13 Sept 2022;<br>Wednesday 14 Sept 2022;<br>Thursday 15 Sept 2022;<br>Friday 16 Sept 2022;<br>Wednesday 21 Sept 2022,<br>Thursday 22 Sept 2022;<br>Friday 23 Sept 2022. |
| The Examination Board will assess candidates' qualifications and interview with a mark **out of 100** (maximum mark for qualifications 20, research proposal 40 and interview 40). | |

Candidates awarded less than **10 marks** for the **qualification evaluation** will not be admitted to the research proposal phase of the selection process.
The minimum pass mark for the **evaluation of the research proposal** is 2**0**.
The minimum pass mark for the **interview is 20**.

**The minimum overall pass mark for the selection procedure is 50.**

The results of the Board's assessment for qualifications and research proposals will be published on the Esse3 portal in the private area of each candidate. No other direct notification will be sent to the candidates.

At the end of the examination procedure, the Board will carry out an overall assessment and draw up an admission rankings list on the basis of the marks obtained by candidates in each part of the examination.

Grants are assigned on the basis of the rankings list, marks obtained and preferences expressed in the application.

The assessment criteria for qualifications will be established by each Examination Board.

**LIST OF RESEARCH TOPICS FOLLOWS**

GRANT N. 1

DAUSY

GRANT di Ateneo

Tematica: "*Decision and Control Techniques for Intelligent Diagnostic and Surgery Using Digital Twins*"

**Research theme title:**

Decision and Control Techniques for Intelligent Diagnostic and Surgery Using Digital Twins

**Contacts:**

Prof. Mariagrazia Dotoli

e-mail: mariagrazia.dotoli@poliba.it

**Curriculum of DAUSY:**

C3 AS for Monitoring and Security

**Hosting University/Research Centre**

Polytechnic of Bari, Italy

**Department:**

Department of Electrical and Information Engineering

via Orabona 4, 70125 Bari - Italy

https://deipoliba.azurewebsites.net/en/department/

**Prospective Supervisors:**

Prof. Mariagrazia Dotoli (http://dclab.poliba.it/people/mariagrazia-dotoli/)

Prof. Vitoantonio Bevilacqua (http://labinfind.poliba.it/people/vitoantonio-bevilacqua/)

**Description:**

Digital twins (DTs) are virtual replicas of physical entities that go beyond a still image and encompass the dynamic functionality of the real-life object. Widely used in industries such as construction and aviation, the DT concept is being recently applied in the healthcare industry with the aim of creating molecular and phenotypic copies of human beings that can allow, for instance, to trial different therapies to elucidate the most efficacious treatment for the real-life patient. DTs can be also employed to improve diagnosis and treatment using the integration and clinical exploitation of complex data. Applied to medicine and public health, DTs enable learning and discovering new knowledge, new hypothesis generation, and testing. They are poised to play a key role in formulating highly personalized treatments and interventions in the future.
Against this background, this project will develop decision and control tools that address the emerging need of intelligent supporting systems for the diagnostics and surgery of severe diseases such as tumors. On the one hand, the DT of a patient will be created with the aim of offering to the medical team a preview of the intervention area and access routes, with a detailed and interactively editable view. On the other hand, a simulator (based on machine learning and optimization techniques) will be developed so that the surgery can be planned in multidisciplinary team meetings, practiced and optimized beforehand, and referenced during

the operation to verify anatomy and avoid inadvertent damage to structures. The real-time model of the patient will also give rise to clinical trials where new instruments, techniques or therapies are first tried on the DT, thus minimizing risks to the patient.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., optimization, control, and deep learning). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

## References:

[1]. Esteva, A. et al. Deep learning-enabled medical computer vision. npj Digit. Med 4,5 (2021).
[2]. Chadebecqa F. et al. Computer Vision in the Surgical Operating Room.
[3]. Sielhorst T. et al. (2006) Depth perception-a major issue in medical AR: evaluation study by twenty surgeons. MICCAI. Springer, pp 364–372.
[4]. Gu, W., Martin-Gomez, A., Cho, S.M.et al. The impact of visualization paradigms on the detectability of spatial misalignment in mixed reality surgical guidance. Int J CARS (2022).
[5]. Frangi F. et al (2018). Higher Order of Motion Magnification for Vessel Localisation in Surgical Video. Medical Image Computing and Computer Assisted Intervention – MICCAI 2018 Volume 11073.
[6]. Anatole Lécuyer; Simulating Haptic Feedback Using Vision: A Survey of Research and Applications of Pseudo-Haptic Feedback. Presence: Teleoperators and Virtual Environments 2009; 18 (1): 39–53.
[7]. Pepe, A., Trotta, G.F., Mohr-Ziak, P., Gsaxner, G., Wallner, J. Bevilacqua., V., Egger, J. A Marker-Less Registration Approach for Mixed Reality–Aided Maxillofacial Surgery: a Pilot Evaluation. J Digit Imaging 32, 1008–1018 (2019). Doi: 10.1007/s10278-019-00272-6.
[8]. Bevilacqua, V., Pietroleonardo, N., Triggiani, V., Brunetti, A., Di Palma, A. M., Rossini, M., Gesualdo, L. An innovative neural network framework to classify blood vessels and tubules based on Haralick features evaluated in histological images of kidney biopsy. Neurocomputing, 228, 143-153 (2017). Doi: 10.1016/j.neucom.2016.09.091
[9]. Bevilacqua, V., Brunetti, A., Guerriero, A., Trotta, G. F., Telegrafo, M., & Moschetta, M. A performance comparison between shallow and deeper neural networks supervised classification of tomosynthesis breast lesions images. Cognitive Systems Research, 53, 3-19 (2019). Doi: 10.1016/j.cogsys.2018.04.011

## Type of scholarship:

Project funded by the Hosting Institution

## Study and research period outside the Hosting Institution:

Eventual study and research period abroad:

- period length: 6 months;
- Hosting institution:
  - University of Edinburgh
  - School of Engineering – Bioengineering Research Institute
  - https://www.eng.ed.ac.uk/research/institutes/ibioe/about
    https://www.eng.ed.ac.uk/about/people/dr-filippo-menolascina

Finanziato dall'Unione europea NextGenerationEU

GRANT N. 2

DAUSY

GRANT CNR

Tematica: "*Advanced learning and control methods with life science applications*"

**Research theme title:**

Advanced learning and control methods with life science applications

**Contacts:**

Alessandro Borri

e-mail: alessandro.borri@iasi.cnr.it

Fabrizio Dabbene

e-mail: fabrizio.dabbene@ieiit.cnr.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Consiglio Nazionale delle Ricerche

**Department:**

DIITET - Dipartimento di Ingegneria, ICT e Tecnologie per l'Energia e i Trasporti

**Prospective Supervisors:**

Alessandro Borri (alessandro.borri@iasi.cnr.it)

Fabrizio Dabbene (fabrizio.dabbene@ieiit.cnr.it)

**Description:**

The core activities of this PhD will be centered on efficient techniques for modeling, learning and control of complex systems arising in life sciences, with focus on biological and medical systems. Examples of such models involve molecular systems biology, glucose-insulin regulatory system, tumor growth and treatment, cardio-respiratory dynamics and control, neurosciences. On the methodological side, the PhD will investigate modern machine learning techniques for the modeling and identification of the system, and advanced control techniques such as hybrid and model predictive control approaches.

**Specific Information:**

A good background in systems and control theory and machine learning is required. A good mathematical background is preferred. Some background in biology is welcome.

**References:**

[1]. G. Pillonetto, T. Chen, A. Chiuso, G. De Nicolao, L. Ljung, *Regularized System Identification - Learning Dynamic Models from data*, Springer, 2022.
[2]. U. Alon, *An introduction to systems biology: design principles of biological circuits*, CRC press, 2019.
[3]. J. Keener, J. Sneyd, eds., *Mathematical physiology*, New York, NY: Springer New York, 2009.
[4]. K. J. Åström, R. M. Murray, *Feedback Systems*, Princeton university press, 2010.

## Type of scholarship:

Project funded by the Hosting Institution

## Study and research period outside the Hosting Institution:

A possible period of 6 to 12 months of the study may be optionally performed as a research period abroad, in an institution to be defined later.

GRANT N. 3

DAUSY

GRANT di Ateneo

Tematica: *"Model based security and monitoring system for resilient industrial control systems"*

**Research theme title:**

Model based security and monitoring system for resilient industrial control systems

**Contacts:**

Prof. Federica Pascucci

e-mail: federica.pascucci@uniroma3.it

**Curriculum of DAUSY:**

C3 AS for Monitoring and Security

**Hosting University/Research Centre**

Università degli Studi Roma Tre

**Department:**

Dipartimento di Ingegneria

Via Vito Volterra, 62 – 00144 Roma – Italy

https://ingegneria.uniroma3.it

**Prospective Supervisors:**

Prof. Federica Pascucci (federica.pascucci@uniroma3.it)

Prof. Stefano Panzieri (stefano.panzieri@uniroma3.it)

**Description:**

Over the past decade, industrial control systems have experienced a massive integration with information technologies. Industrial networks have undergone numerous technical transformations to protect operational and production processes, leading today to a new industrial revolution. Nowadays, indeed, industrial control devices are one of the major targets for hackers due to their exposure to threats: the principle of "air gaps" (disconnecting the industrial control network from the operational networks) is not anymore feasible in a connected world. Despite the importance of protecting such systems, cybersecurity related issues have not been given due consideration.

The goal of this project is to improve the security and the resilience of cyber physical systems by exploiting early detection and risk analysis. The research project will fall in the cross-cutting edges among control engineering, cybersecurity, and machine learning. The application area will be focused on digital control systems operated over communication networks prone to cyber-attacks.

The research will focus on developing novel system analysis and design methodologies that jointly consider both the risk (i.e., impact and cascading effects) and detectability of attacks under uncertainties. It will exploit model-based approaches related to fault diagnosis and data-driven solutions such as machine learning. The developed methods shall support the design of anomaly detection and control algorithms for improving security and resilience. These algorithms will be validated by simulation and on experimental testbeds.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., Cybersecurity, Control Engineering, Computer Systems and Networks, Automation, and Machine Learning). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should have the ability to work independently and to collaborate with teams. A positive attitude to problem solving for complex systems is strongly required.

## References:

[1]. Sandberg, Henrik and Johansson, Karl H. and Gupta, Vijay, Secure Networked Control Systems (May 2022). Annual Review of Control, Robotics, and Autonomous Systems, Vol. 5, pp. 445-464, 2022.
[2]. R. Ferrari, A. M. H. Teixeira. "A Switching Multiplicative Watermarking Scheme for Detection of Stealthy Cyber-Attacks". IEEE Transactions on Automatic Control, 2020.
[3]. R. Taormina, S. Galelli, H. C. Douglas, N. O. Tippenhauer, E. Salomons, A. Ostfeld, A toolbox for assessing the impacts of cyber-physical attacks on water distribution systems. Environmental Modelling & Software, 2019.
[4]. M. H. Teixeira, I. Shames, H. Sandberg, and K. H. Johansson. "A Secure Control Framework for Resource-Limited Adversaries". Automatica, vol. 51, pp. 135-148, Jan. 2015.
[5]. R. M. G. Ferrari, T. Parisini and M. M. Polycarpou, "Distributed Fault Diagnosis With Overlapping Decompositions: An Adaptive Approximation Approach," in IEEE Transactions on Automatic Control, vol. 54, no. 4, pp. 794-799, April 2009.

## Type of scholarship:

Project funded by the Hosting Institution

## Study and research period outside the Hosting Institution:

- Period length: up to 6 months;
- University of Coimbra – Centre for Informatics and Systems
- Polo II, Pinhal de Marrocos, 3030-290 Coimbra, Portugal
- https://www.uc.pt – https://www.cisuc.uc.pt/

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 4
# DAUSY

## GRANT di Ateneo

## Tematica: *"Performance-aware and resilient supervisory control of cyber-physical and industrial automation systems"*

**Research theme title:**

Performance-aware and resilient supervisory control of cyber-physical and industrial automation systems

**Contacts:**

Prof. Francesco Basile

Email: fbasile@unisa.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Università degli Studi di Salerno

**Department:**

D.I.E.M.
Dipartimento di Ingegneria dell'informazione ed elettrica e matematica applicata
Via Giovanni Paolo II, 132
84084 Fisciano (SA), ITALY

https://www.diem.unisa.it/

**Prospective Supervisors:**

Prof. Francesco Basile (http://docenti.unisa.it/francesco.basile)

**Description:**

Today's technological society is permeated by complex systems composed by multiple smart elements and devices interacting together by way of communication networks, often called distributed cyber-physical systems (CPSs). Examples of CPSs are connected autonomous vehicle systems, automated warehouse systems, smart grids and buildings. Many computing subsystems in CPSs and industrial automation control systems are based on commercial-off-the-shelf smart components, endowed with communication capabilities. These components provide a significant level of control, lower deployment and operational costs in comparison to the traditional vendor-specific proprietary and closed-source systems. However, the coordination of these components to guarantee certain performance levels represents a challenging problem. In addition, they expose the control systems to vulnerabilities and threats.

There is a great potential in this area for developing novel approaches using methodologies that pertain to discrete event systems (DESs). Indeed, both the coordination and the cyber-attacks affect essentially the higher levels of the control architecture, where the discrete event view of the system is the most effective description of the system dynamics.

The goal of the research is to improve the state of the art by using timed models for the synthesis of supervisory control systems guaranteeing a certain performance level and also resilience against cyber-attacks.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., optimization, control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. João Carlos Basilio, Christoforos N. Hadjicostis and Rong Su, Analysis and Control for resilience of Discrete Event Systems: Fault Diagnosis, Opacity and Cyber Security, Foundations and Trends® in Systems and Control: Vol. 8: No. 4, 2021.
[2]. Christos G. Cassandras, Stéphane Lafortune, Introduction to Discrete Event Systems, Springer Cham, 2021.
[3]. Christoforos N. Hadjicostis, Estimation and Inference in Discrete Event Systems A Model-Based Approach with Finite Automata, Springer Cham, 2020.
[4]. Carla Seatzu, Manuel Silva, Jan H. van Schuppen, Control of Discrete-Event Systems: Automata and Petri Net Perspectives, Springer London, 2013.

## Type of scholarship:

Project funded by the Hosting Institution

## Study and research period outside the Hosting Institution:

Minimum 6, maximum 12 months of the study shall be performed as a research period abroad, in an institution to be defined later.

Finanziato dall'Unione europea NextGenerationEU

# GRANT N. 5

## DAUSY

## GRANT di Ateneo
## Tematica: *"Awareness in human-human and human-robot interactions"*

**Research theme title:**

Awareness in human-human and human-robot interactions

**Contacts:**

Prof. Chiara Mocenni

e-mail: chiara.mocenni@unisi.it

**Curriculum of DAUSY:**

C1 - AS for Automation

**Hosting University/Research Centre**

University of Siena, Italy

**Department:**

Department of Information Engineering and Mathematics (DIISM),

University of Siena

Via Roma, 56 - 53100 - Siena

Tel +39 0577 235897 - amministrazione.diism@unisi.it

PEC: pec.diism@pec.unisipec.it

Website: www.dii.unipi.it

**Prospective Supervisors:**

Prof. Chiara Mocenni (chiara.mocenni@unisi.it)

Prof. Domenico Prattichizzo (domenico.prattichizzo@unisi.it)

**Description:**

The aim of the training project is to study the impact of awareness on individual decision-making processes in different scenarios, such as human-human, human-robot, and human-environment interactions. This is an important aspect in many different fields as we might expect that in all cases, the higher the individuals' level of awareness, the higher their well-being. Cognitive and behavioral factors, involved in awareness and self-awareness, will be investigated to understand the mechanisms of individual and group decision-making. Moreover, since robot devices that establish a functional relationship with a human give rise to complex human-technology systems, the aim of the research will be to develop suitable interpretive models from a cognitive viewpoint, as well as new principles and evaluative models from a moral viewpoint. Moreover, our purpose is to analyze the impact that aware decisions may have on environmental management, and, on the other hand, how extreme environmental events affect human behavior. The efforts in understanding

awareness will allow us to design technologies and methodologies considering all the cognitive, social, ethical, and environmental implications related to their adoption.

### Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., machine learning, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

### References:

[1]. Bizzarri F., and Mocenni C., "Awareness", Academia Letters, 2022.
[2]. Madeo D., Mannarini T. Salvatore S., and Mocenni C., "Modeling pluralism and self-regulation explains the emergence of cooperation in networked societies", Scientific Reports, 11, 19226, 2021.
[3]. Unger L., Sloutsky V.M., "Ready to Learn: Incidental Exposure Fosters Category Learning", Psychological Science. May 2022.
[4]. Casalino A., Messeri C., Pozzi M., Zanchettin A. M., Rocco P., and Prattichizzo D., "Operator Awareness in Human–Robot Collaboration Through Wearable Vibrotactile Feedback," in IEEE Robotics and Automation Letters, vol. 3, no. 4, pp. 4289-4296, 2018.
[5]. Kahneman D., Thinking, fast and slow, Penguin Books, 2011.

### Type of scholarship:

The scholarship will be financed by research grants of the PhD supervisors

### Study and research period outside the Hosting Institution:

Duration of the study and research period at the company or research center or Public Administration: 6 to 12 months

Name of receiving company or public administration: to be defined

Duration of the study and research period abroad: 6 to 18 months

Name of receiving institution: to be defined

Finanziato dall'Unione europea
NextGenerationEU

GRANT N. 6

DAUSY

D.M. 351/2022

Ambito: Pubblica Amministrazione
Tematica: "Decision and Control Techniques for Energy Management of Smart Cities"

**Research theme title:**

Decision and Control Techniques for Energy Management of Smart Cities

**Contacts:**

Prof. Mariagrazia Dotoli

e-mail: mariagrazia.dotoli@poliba.it

**Curriculum of DAUSY:**

C3 AS for Monitoring and Security

**Hosting University/Research Centre**

Polytechnic of Bari, Italy

**Department:**

Department of Electrical and Information Engineering

via Orabona 4, 70125 Bari - Italy

https://deipoliba.azurewebsites.net/en/department/

**Prospective Supervisors:**

Prof. Mariagrazia Dotoli (http://dclab.poliba.it/people/mariagrazia-dotoli/)

Dr. Raffaele Carli (http://dclab.poliba.it/people/raffaele-carli/)

**Description:**

A smart city is a sustainable and efficient urban centre that provides a high quality of life to its inhabitants through optimal management of its resources. Energy management is one of the most demanding issues within such urban centres owing to the complexity of the energy systems and their vital role. As a consequence, to increase smartness, cities should improve present systems and implement new solutions in a coordinated way and through an optimal approach, by profiting from the synergies among all the involved urban actors. Against this background, this project will develop decision and control tools that address the emerging need of intelligent energy management systems for smart cities and related subsystems such has energy clusters, districts, communities, smart buildings, and smart homes. On the one hand, optimization tools devoted to the strategic management of urban energy systems will be investigated to make urban infrastructure and facilities more energy efficient and environmentally friendly in a cost effective manner. On the other hand, this project will define decision and control techniques for the operational management of urban smart energy systems,

with the final aim of ensuring the transition towards a low-carbon energy sector and the efficient and sustainable use of natural resources from users' perspective.
The research will be applied to real urban case studies in collaboration with the Smart Cities and Communities Laboratory of the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA).

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

## References:

[1]. Calvillo, Christian F., Alvaro Sánchez-Miralles, and Jose Villar. "Energy management and planning in smart cities." Renewable and Sustainable Energy Reviews 55 (2016): 273-287.
[2]. Carli, R., Dotoli, M., Pellegrino, R., "A Hierarchical Decision Making Strategy for the Energy Management of Smart Cities", IEEE TASE (Transactions on Automation Science and Engineering), vol. 14, no. 2, pp. 505-523, 2017.
[3]. Carli, R., Dotoli, M., Pellegrino, R.; Ranieri, L., "A decision making technique to optimize a building stock energy efficiency", IEEE SMC-A (Transactions on Systems, Man and Cybernetics: Systems), vol. 47, no. 5, pp. 794-807, 2017.
[4]. Carli, R.; Dotoli, M.; Pellegrino, R., "A decision-making tool for energy efficiency optimization of street lighting," Computers and Operations Research (2018), vol. 96, pp. 223-235, 2018.
[5]. Scarabaggio P.; Grammatico S.; Carli, R.; Dotoli, M., "Distributed Demand Side Management with Stochastic Wind Power Forecasting", IEEE Transactions on Control Systems Technology (TCST), vol. 30, no. 1, pp. 97-112, 2022.
[6]. Carli, R. and Dotoli, M., "Decentralized Control for Residential Energy Management of a Smart Users' Microgrid with Renewable Energy Exchange," IEEE/CAA Journal of Automatica Sinica, vol. 6, no. 3, pp. 641-656, 2019.
[7]. Carli, R.; Dotoli, M.; Jantzen, J.; Kristensen, M.; Othman, S. B., "Energy Scheduling of a Smart District Microgrid with Shared Photovoltaic Panels and Storage: the case of the Ballen marina in Samsø", Energy – The International Journal, 198, 117188, 2020.
[8]. Hosseini, S. M.; Carli, R.; Dotoli, M., "Robust Optimal Energy Management of a Residential Microgrid under Uncertainties on Demand and Renewable Power Generation," IEEE Transactions on Automation Science and Engineering (TASE), vol. 18, no. 2, pp. 618-637, 2021.
[9]. Carli, R.; Cavone, G.; Pippia, T.; De Schutter, B.; Dotoli, M., "Robust Optimal Control for Demand Side Management of Multi-Carrier Microgrids", in IEEE Transactions on Automation Science and Engineering (TASE), 2022.

## Type of scholarship:

DM 351/2022 - Project on Public Administration

## Study and research period outside the Hosting Institution:

1. Study and research period at research center:
   - period length: 6 months;

- Hosting center:
  - ENEA - Smart Cities and Communities Laboratory
  - Via Anguillarese, 301 00123 S.Maria di Galeria (Roma)
  - https://www.casaccia.enea.it/ - https://energia.enea.it/divisioni/smart-energy/

2. Study and research period abroad:

- period length: 6 months;
- Hosting institution:
  - Universitat Politècnica de Catalunya - Automatic Control Department
  - Llorens i Artigas 4-6 08028 Barcelona, Spain
  - https://www.iri.upc.edu/research/automatic_control

GRANT N. 7
DAUSY

D.M. 351/2022
Ambito: PNRR
Tematica: “Smart control systems for rural energy communities”

**Research theme title:**

Smart control systems for rural energy communities

**Contacts:**

Prof. Mariagrazia Dotoli

e-mail: mariagrazia.dotoli@poliba.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

Polytechnic of Bari, Italy

**Department:**

Department of Electrical and Information Engineering

via Orabona 4, 70125 Bari - Italy

https://deipoliba.azurewebsites.net/en/department/

**Prospective Supervisors:**

Prof. Mariagrazia Dotoli (http://dclab.poliba.it/people/mariagrazia-dotoli/)

Dr. Raffaele Carli (http://dclab.poliba.it/people/raffaele-carli/)

**Description:**

Over the decades, both the rural sector and energy grids have encountered significant challenges, such as the lack of power supply to agricultural farms and the difficulties of renewable energy use in electricity networks. To overcome and address these issues, this project will develop new decision and control techniques aimed at merging smart farms, renewable energy, and rural small consumers into Rural Energy Communities (RECs), using surplus renewable energy and distributed storage for the agriculture sector and the smart farm.
The overall objective of this project is thus to define new control architectures and frameworks for RECs, as enabling tools to transform the rural grid from a rigid and weak system to a flexible and sustainable asset. In particular, control mechanisms integrating optimization, game theory, and learning will be developed aimed at making RECs capable of conveniently integrating smart farms and greenhouses. Thanks to the innovative control framework and leveraging on loads flexibility, these REC stakeholders will be enabled to trade local energy exchanges, optimally share common energy resources, and pursue instantaneous self-consumption, while reducing overall costs and improving sustainability.

This project will devote particular attention to highlighting the peculiarities of rural energy distribution with respect to urban energy communities and will target the need of gaining substantial improvements in terms of network resilience and efficiency, favouring the introduction of innovative control frameworks in support of rural energy systems operations and of their future economic and industrial sustainability.

**Specific Information:**

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

**References:**

[1]. R. K. Chauhan, K. Chauhan, and S. N. Singh, "Overview of microgrids for rural areas and low-voltage applications," Microgrids Rural Areas, vol. 1, pp. 3–12, 2020.
[2]. V. Z. Gjorgievski, S. Cundeva, and G. E. Georghiou, "Social arrangements, technical designs and impacts of energy communities: A review," Renew. Energy, vol. 169, pp. 1138–1156, 2021.
[3]. S. Sen and V. Kumar, "Microgrid control: A comprehensive survey," Annu. Rev. Control, vol. 45, no. June, pp. 118–151, 2018.
[4]. E. Hammad, A. Farraj, and D. Kundur, "Cooperative microgrid networks for remote and rural areas," Can. Conf. Electr. Comput. Eng., vol. 2015-June, no. June, pp. 1572–1577, 2015.
[5]. E. E. Gaona, C. L. Trujillo, and J. A. Guacaneme, "Rural microgrids and its potential application in Colombia," Renew. Sustain. Energy Rev., vol. 51, pp. 125–137, 2015.
[6]. C. Bersani, H. Dagdougui, A. Ouammi, and R. Sacile, "Distributed Robust Control of the Power Flows in a Team of Cooperating Microgrids," IEEE Trans. Control Syst. Technol., vol. 25, no. 4, pp. 1473–1479, 2017.
[7]. A. Boccalatte, M. Fossa, and R. Sacile, "Modeling, Design and Construction of a Zero-Energy PV Greenhouse for Applications in Mediterranean Climates," Therm. Sci. Eng. Prog., vol. 25, 2021.
[8]. P. Scarabaggio, S. Grammatico, R. Carli, and M. Dotoli, "Distributed Demand Side Management with Stochastic Wind Power Forecasting," IEEE Trans. Control Syst. Technol., vol. 30, no. 1, pp. 97–112, 2022.
[9]. R. Carli, M. Dotoli, J. Jantzen, M. Kristensen, and S. Ben Othman, "Energy scheduling of a smart microgrid with shared photovoltaic panels and storage: The case of the Ballen marina in Samsø," Energy, vol. 198, p. 117188, 2020.
[10]. C. Bersani, A. Ouammi, R. Sacile, and E. Zero, "Model predictive control of smart greenhouses as the path towards near zero energy consumption," Energies, vol. 13, no. 14, 2020.

**Type of scholarship:**

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

**Study and research period outside the Hosting Institution:**

1. Study and research period abroad:
   - period length: 6 months;
   - Hosting institution:
     - Delft University of Technology – Delft Center for Systems and Control
     - C-3-250, Mekelweg 2, 2628 CD Delft, The Netherlands
     - https://www.tudelft.nl/3me/over/afdelingen/delft-center-for-systems-and-control

GRANT N. 8

DAUSY

D.M. 351/2022

Ambito: Pubblica Amministrazione
Tematica: “Learning and control of complex networks and financial systems”

**Research theme title:**

Learning and control of complex networks and financial systems

**Contacts:**

Prof. Giuseppe Calafiore

e-mail: giuseppe.calafiore@polito.it

Dr. Giulia Fracastoro

e-mail giulia.fracastoro@polito.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

Politecnico di Torino

**Department:**

Dipartimento di Elettronica e Telecomunicazioni

Corso Duca degli Abruzzi 24, 10129 Torino

https://www.det.polito.it/it/

**Prospective Supervisors:**

Giuseppe Calafiore (giuseppe.calafiore@polito.it)

Giulia Fracastoro (giulia.fracastoro@polito.it)

**Description:**

The core activities of this PhD will be centered on efficient techniques for the modeling and control of complex networked systems. From the methodological side, we shall explore linear and nonlinear techniques for identification/learning of complex models of interconnected systems from available observed data, and control techniques for influencing the system in order to obtain a desired behavior. These techniques will be applied to practical models such as pandemic evolution models and financial liability networks, and will inform public decision makers for designing appropriate crisis management policies.

**Specific Information:**

Good background is required in probability and statistics, system identification, systems and control theory and machine learning.

## References:

[1]. Dynamic Planning of a Two-Dose Vaccination Campaign with Uncertain Supplies, European Journal of Operational Research, 2022
[2]. Age structure in SIRD models for the COVID-19 pandemic—A case study on Italy data and effects on mortality, Plos One, 2022
[3]. A time-varying SIRD model for the COVID-19 contagion in Italy, Annual Reviews in Control, 2020
[4]. On Optimal Clearing Payments in Financial Networks, 2021 60th IEEE Conference on Decision and Control (CDC)
[5]. Control of Dynamic Financial Networks (The Extended Version), arXiv preprint, 2022

## Type of scholarship:

DM 351/2022 – Project on Public Administration

## Study and research period outside the Hosting Institution:

- minimum 6, maximum 18 months of the study shall be performed at a company or research center or Public Administration. In particular, the PhD candidate, will spend 6 months in the research center of IEIIT-CNR, Torino. https://www.ieiit.cnr.it/it/
- minimum 6, maximum 18 months of the study shall be performed as a study and research period abroad. In particular, the PhD candidate, will spend 6 months at the College of Engineering and Computer Science of VinUniversity in Hanoi, Vietnam. https://vinuni.edu.vn/college-of-engineering-computer-science/

Finanziato dall'Unione europea
NextGenerationEU

GRANT N. 9

DAUSY

D.M. 351/2022
Ambito: PNRR
Tematica: "Machine learning paradigms for fast and faithful approximations of model predictive controllers"

**Research theme title:**

Machine learning paradigms for fast and faithful approximations of model predictive controllers

**Contacts:**

Prof. Alberto Bemporad

e-mail: alberto.bemporad@imtlucca.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

IMT School for Advanced Studies Lucca, Italy

**Department:**

IMT School for Advanced Studies

Piazza S. Francesco 19, 55100, Lucca, Italy

https://www.imtlucca.it/

**Prospective Supervisors:**

Prof. Alberto Bemporad (http://cse.lab.imtlucca.it/~bemporad/)

Dr. Filippo Fabiani (filippo.fabiani@eng.ox.ac.uk)

**Description:**

The contemporary quest for easily embeddable control systems with increasing efficiency is shedding light on the impressive potential of machine learning approaches to design proxies for traditional, possibly model-based, control techniques. Among them, model predictive control (MPC) has been shown to benefit the most since surrogate MPC-based policies synthesized through machine learning paradigms typically feature almost inexpensive online evaluation while retaining some flavour of optimality.

Nevertheless, accompanying those learning-based controllers with rigorous certificates demonstrating their reliability in terms of stability and performance of the closed-loop system when called to replace the original MPC law based on online optimization denotes a key challenge. Therefore, the PhD student will investigate a combination of machine learning and control theoretical methods to approximate MPC laws outperforming the original policy from a computational perspective, while retaining rigorously-proven stability properties. Relevant approaches may hence look in several directions, including for instance active learning to reduce the number of samples and the corresponding computational effort required to learn the approximate MPC law; supervised/unsupervised learning with possible dual-mode implementation to safely merge optimal explicit solutions and deep neural approximations; learning dynamic output-feedback MPC laws by using recurrent

neural networks. The thesis will thus focus on the theoretical soundness of the proposed approaches to learning-based controller approximation, algorithmic aspects, and on testing the effectiveness of the developed methods on case-studies of practical relevance spanning from automotive and aerospace applications to industrial process and energy dispatch control.

## Specific Information:

We are looking for a motivated and talented PhD student with strong mathematical background in systems and control, numerical optimization, and machine learning. Coding skills, as well as proficiency in both spoken and written English, are required.

## References:

[1]. Bemporad, A. (2022). A piecewise linear regression and classification algorithm with application to learning and model predictive control of hybrid systems. *IEEE Transactions on Automatic Control* (conditionally accepted for publication).
[2]. Bemporad, A. (2021). Training recurrent neural networks by sequential least squares and the alternating direction method of multipliers. *arXiv preprint arXiv:2112.15348*.
[3]. Bemporad, A., Morari, M., Dua, V., & Pistikopoulos, E. N. (2002). The explicit linear quadratic regulator for constrained systems. *Automatica*, *38*(1), 3-20.
[4]. Breschi, V., Piga, D., & Bemporad, A. (2016). Piecewise affine regression via recursive multiple least squares and multicategory discrimination. *Automatica*, *73*, 155-162.
[5]. Fabiani, F., & Goulart, P. J. (2021). Reliably-stabilizing piecewise-affine neural network controllers. *arXiv preprint arXiv:2111.07183*.
[6]. Fabiani, F., & Goulart, P. J. (2022). Neural network controllers for uncertain linear systems. *arXiv preprint arXiv:2204.13209*.
[7]. Hewing, L., Wabersich, K. P., Menner, M., & Zeilinger, M. N. (2020). Learning-based model predictive control: Toward safe learning in control. *Annual Review of Control, Robotics, and Autonomous Systems*, *3*, 269-296.
[8]. Karg, B., & Lucia, S. (2020). Efficient representation and approximation of model predictive control laws via deep learning. *IEEE Transactions on Cybernetics*, *50*(9), 3866-3878.
[9]. Maddalena, E. T., Moraes, C. D. S., Waltrich, G., & Jones, C. N. (2020). A neural network architecture to learn explicit MPC controllers from data. *IFAC-PapersOnLine*, *53*(2), 11362-11367.
[10]. Mayne, D. Q., Rawlings, J. B., Rao, C. V., & Scokaert, P. O. (2000). Constrained model predictive control: Stability and optimality. *Automatica*, *36*(6), 789-814.

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

- Period length: 6 months;
- Hosting institution:
  - University of Oxford - Department of Engineering Science
  - Parks road OX1 3PJ, Oxford - United Kingdom
  - https://www.ox.ac.uk/ - https://eng.ox.ac.uk/

GRANT N. 10

DAUSY

D.M. 351/2022
Ambito: PNRR
Tematica: “Model-based and data-driven learning and control of complex network systems”

**Research theme title:**

Model-based and data-driven learning and control of complex network systems

**Contacts:**

Prof. Gianfranco Parlangeli

e-mail: gianfranco.parlangeli@unisalento.it

**Curriculum of DAUSY**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Salento

**Department:**

Department of Engineering for Innovation

Via per Monteroni

https://www.dii.unisalento.it/

**Prospective Supervisors:**

Prof. Gianfranco Parlangeli (https://www.unisalento.it/scheda-utente/-/people/gianfranco.parlangeli/)

Prof. Giuseppe Notarstefano (https://www.unibo.it/sitoweb/giuseppe.notarstefano/en)

**Description:**

The recent technology advances involving interconnected intelligent devices have posed new challenges in the design paradigms for complex systems. The interconnection topology and the local protocols fundamentally affect the dynamical processes of these complex networks and generate relevant collective features (such as aggregation/collaboration, consensus or clustering). Moreover, subsets of nodes may condition the global evolution or may be used to retrieve information on other nodes. Exploring the capabilities of the complex network and identifying main features of the network structure is a research challenge to address that can have a significant impact in several domains as traffic control, social networks, or swarm robotics. The interconnection among network clusters is often affected by adjustable local interaction, so that the value of local parameters may have a strong impact on the overall system performance. The design and tuning of these local interactions and parameters, e.g., by minimizing suitable global performance metrics (e.g., energy consumption) is a challenge to be addressed. Moreover, a timely research direction involves the combination

of model-based system-theoretical tools with data-driven approaches (e.g., from Artificial Intelligence) that have shown to be extremely successful in several domains and that allow the designer to take advantage from the availability of massive data.

Considering the above framework, the proposed PhD program will deal with: (i) the investigation of network features with their impact on global behaviors and fundamental limitations of the complex system, (ii) novel approaches for the design of local interactions by taking into account performance indexes and global constraints, and (iii) the exploration of combined system theoretical approaches and data-driven tools to learn and control the network system. The developed methodological studies will be applied to concrete applications scenarios from cooperative robotics.

## Specific Information:

Applicants must hold a master's degree in scientific disciplines, preferably in the area of Automation, Electrical or Information Engineering, Computer Science or Mathematics. Prior knowledge on control theory is required, prior knowledge on optimization and spectral graph theory is a plus. Confidence with the English language (B2 level) is required, proficiency in both spoken and written English is welcome. Good experience and confidence with mathematical simulation software is strongly recommended.

## References:

[1]. Spectrum of controlling and observing complex networks. Yan, G., Tsekenis, G., Barzel, B., Slotine, J. J., Liu, Y. Y., & Barabási, A. L. (2015). Nature Physics, 11(9), 779-786.
[2]. Sultangazin, A., Pannocchi, L., Fraile, L., & Tabuada, P. (2022). Learning to control from expert demonstrations. *arXiv preprint arXiv:2203.05012*.
[3]. Tian, Y., Wang, L., & Bullo, F. (2022). How social influence affects the wisdom of crowds in influence networks. *arXiv preprint arXiv:2204.13610*.
*[4].* -Yan, R., Duan, X., Shi, Z., Zhong, Y., Marden, J. R., & Bullo, F. (2021). Policy Evaluation and Seeking for Multi-Agent Reinforcement Learning via Best Response. *IEEE Transactions on Automatic Control Volume: 67, Issue: 4, April 2022*
[5]. Network Design for Controllability Metrics C. O. Becker, S. Pequito, G. J. Pappas, V. M. Preciado IEEE Transactions on Control of Network Systems, Vol. 7: 3, Sept. 2020
[6]. Asymmetric Coupling Optimizes Interconnected Consensus Systems Z Song, D Taylor - arXiv preprint arXiv:2106.13127, 2021

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

The study and research period abroad are expected to last from 6 to 9 months;

Hosting institution: Prof. Gesualdo Scutari

https://engineering.purdue.edu/~gscutari/

Purdue University
West Lafayette, IN, 47907-5400, USA

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 11

# DAUSY

## D.M. 351/2022
## Ambito: PNRR
## Tematica: "Emergent behaviors in opinion dynamics"

**Research theme title:**

Emergent behaviors in opinion dynamics

**Contacts:**

Prof. Francesco Vasca

e-mail: vasca@unisannio.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Sannio, Benevento, Italy

**Department:**

Department of Engineering

Piazza Roma 21, 82100 Benevento, Italy

https://www.ding.unisannio.it/

**Prospective Supervisors:**

Prof. Francesco Vasca (https://www.francescovasca.net/)

**Description:**

The research project is the area of analysis of dynamic social networks through graph theory. Dynamic interconnected systems can be represented as switching networks whose paradigm is applicable in different sectors. Opinion dynamics are characterized by relationships between autonomous agents each with its own state dynamics, with connections that depend on the relative distance between the respective state variables. The dynamic behavior is determined by the commutations of the links between the nodes of the network. For this class of systems, network analysis requires advanced modeling and control techniques: from hybrid systems to averaging techniques, from Lyapunov stability to dynamic graphs. The project intends to deepen the aforementioned methodologies, drawing inspiration from applications for the dynamics of opinions in social networks.

**Specific Information:**

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., systems theory, control, graph theory). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

## References:

[1]. C. Bernardo, L. Wang, F. Vasca, Y. Hong, G. Shi, C. Altafini, "Achieving consensus in multilateral international negotiations: The case study of the 2015 Paris Agreement on climate change", Science Advanced, vol. 7, n. 51, 2021, p. 1-16 (open access).
[2]. C. Bernardo, F. Vasca, R. Iervolino, "Heterogeneous Opinion Dynamics with Confidence Thresholds Adaptation", IEEE Transactions on Control of Network Systems, (in press).
[3]. F. Vasca, C. Bernardo, R. Iervolino, "Practical consensus in bounded confidence opinion dynamics'', Automatica, vol. 127, n. 7, 2021, p. 109683 (open access).
[4]. C. Altafini and G. Lini, "Predictable dynamics of opinion forming for networks with antagonistic interactions," IEEE Trans. Autom. Control, vol. 60, no. 2, pp. 342–357, 2015.
[5]. A. Proskurnikov, R. Tempo, "A tutorial on modeling and analysis of dynamic social networks. Part I," Annu. Rev. Control, vol. 43, pp. 65–79, 2017.
[6]. C. Ravazzi, F. Dabbene, C. Lagoa, A. V. Proskurnikov, "Learning hidden influences in large-scale dynamical social networks: A data- driven sparsity-based approach, in memory of Roberto Tempo," IEEE Control Syst. Mag., vol. 41, no. 5, pp. 61–103, 2021.

## Type of scholarship:

DM 351/2022 – PNRR

## Study and research period outside the Hosting Institution:

Study and research period abroad:

- period length: 6 months (at least);
- Hosting institution:
  - Linkoping University, Sweden
  - Prof. Claudio Altafini, http://users.isy.liu.se/en/rt/claal20/

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 12

# DAUSY

## D.M. 351/2022
## Ambito: PNRR
## Tematica: "Control Strategies for Energy Harvesting Systems "

**Research theme title:**

Control Strategies for Energy Harvesting Systems

**Contacts:**

Prof. Alessandro Casavola

e-mail: a.casavola@dimes.unical.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Calabria

**Department:**

Department of Informatics, Modeling, Electronics and Systems Engineering

Via Pietro Bucci, 42/C – 87036 Rende (CS) – Italy

http://www.dimes.unical.it

**Prospective Supervisors:**

Prof. Alessandro Casavola (https://www.unical.it/storage/teachers/alessandro.casavola)

Prof. Francesco Tedesco (https://tedescof.wordpress.com/)

**Description:**

Energy harvesting systems and the related control problems have attracted the attention of many researchers in recent years. Depending on the applicative contexts the energy sources can be different, but the purpose is always that of recovering that energy that would otherwise be lost as heat. In automotive engineering, examples include energy recovering and conversion from exhaust emission in turbocharged car engines, the absorption of the kinetic energy in the brakes, the vibrations of the engines and the suspension systems. If such systems did equip a hybrid or electrical vehicle, the harvested energy could be used to recharge the vehicle's battery and hence extend its mileage. In the context of sensor networks, it provides a means of powering electronics where there are no conventional power sources, eliminating the need for frequent battery replacements and running wires to end applications. This is especially true in underwater or marine applications. The focus of the research will be on the study and development of control strategies suitable for the maximization of the harvested energy while satisfying, at the same time, other control specifications. This is the case, for example, in regenerative suspension systems where the maximization of the energy harvested

by road unevenness has to be traded off with other requirements, such as the desired drive comfort and road handling. In other cases, as in wind-turbine or wave energy conversion, the maximization of the recovered energy is a major concern and the challenges are more related to maintaining the operation within safe operative constraints. It is well known that the optimal solution in most cases is anti-causal (it depends on the future of some exogenous signals) and one of the challenges will be to find suitable causal approximations. Model Predictive Control (or Economic MPC) strategies seem to offer a good starting point for their capability to deal with future predictions of system variables, optimizing the control actions with respect to meaningful cost indices and inherently handling constraints. The research will be assessed by cases study on regenerative suspension systems and marine wave energy conversion set-ups.

Specific Information:

Applicants must hold a master's degree, preferably in Engineering or Physics, with a good background in relevant areas of interest (i.e., Mechanic, Electrical, Optimization, and Control). Solid mathematical and Matlab/Simulink coding skills are preferred. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

References:

[1]. J.V. Ringwood, "Wave energy control: status and perspectives 2020", 21st IFAC World Congress, Berline, Germany, 11-17 July 2020.
[2]. S. Zhan, G. Li, J. Na, W. He, "Feedback noncausal model predictive control of wave energy converters", Control Engineering Practice, Vol. 85, pp. 110-120, April 2019.
[3]. A. Hosseini-Fahraji, P. Loghmannia, K. Zeng, X. Li, S. Yu, S. Sun, D. Wang, Y. Yang, M. Manteghi, and L. Zuo, "Energy Harvesting Long-Range Marine Communication", IEEE Conference on Computer Communications INFOCOM 2020, Toronto, Canada, 06-09 July 2020.
[4]. M.A.A. Abdelkareema, L. Xua, M.K.A. Alia, A. Elagouza, J. Mia, S. Guoa, Y. Liuc, L. Zuo, "Vibration energy harvesting in automotive suspension system: A detailed review", Applied Energy, Vol. 229, pp. 672-699, 2018
[5]. M.R. Hajidavalloo, A. Gupta, Z. Li, W-C. Tai, "MPC-Based Vibration Control and Energy Harvesting using Stochastic Linearization for a New Energy Harvesting Shock Absorber", 2021 IEEE Conference on Control Technology and Applications (CCTA), San Diego, CA, USA, 09-11 August 2021
[6]. A. Casavola, F. Di Iorio, F. Tedesco, "A multiobjective H-inf control strategy for energy harvesting in regenerative vehicle suspension systems", International Journal of Control, Vol. 91, N. 4, pp. 741-754, 2018.

Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

Study and research period outside the Hosting Institution:

1. Study and research period abroad:
- period length: 6 months;
- Hosting institution:
  - Imperial College London - Department of Electrical and Electronic Engineering
  - Exibition Road, London SW7 2BT, UK.
  - https://www.imperial.ac.uk/electrical-engineering/

## GRANT N. 13

## DAUSY

Finanziato dall'Unione europea
NextGenerationEU

# D.M. 351/2022
# Ambito: PNRR
# Tematica: "Supervision and control techniques for energy management in the More Electric Aircraft"

**Research theme title:**

Supervision and control techniques for energy management in the More Electric Aircraft

**Contacts:**

Prof. Alberto Cavallo

e-mail: alberto.cavallo@unicampania.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Università della Campania "Luigi Vanvitelli"

**Department:**

Dipartimento di Ingegneria

via Roma 29, 81031, Aversa (CE)

https://www.ingegneria.unicampania.it

**Prospective Supervisors:**

Alberto Cavallo, alberto.cavallo@unicampania.it

Ciro Natale, ciro.natale@unicampania.it

**Description:**

The More Electric Aircraft concept (MEA) is one of the most discussed topics of the recent decades inside the aircraft field. Basically, it aims to replacing hydraulic, pneumatic and mechanic devices onboard with their electrical counterparts. Obviously, this approach increases the complexity of the electric network onboard, creating drawbacks and opportunities. The main drawback is the impossibility for a human operator to control "manually" all the devices. This in turn calls for advanced automated controllers and supervisors. The opportunities are that within the control logics it is possible to insert optimization objectives in order to improve also energy management onboard, reduce weight (and thus fuel consumption) and implement health-monitoring and fault-management strategies.

All the above objectives require solid mathematical approaches, in order to prove stability and performance of the proposed solutions, also in the presence of strong nonlinearities, uncertainties, quickly varying loads. Another interesting aspect to be addressed is how to implement the proposed strategy, whether using a centralized control or single agents to be coordinated using, e.g., consensus-based approaches. Mathematical modelling at different levels of abstractions is also a crucial activity. Correspondingly, numerical simulation at different levels will be addressed, from simple basic Simulink models to physical modelling and Hardware-in-the-loop software.

## Specific Information:

Applicants must hold a master's degree, preferably in Automation, Electronic or Computer Science Engineering, with a good background in relevant areas of interest (i.e., machine learning, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian logistic company, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. Branicky, M. S. (1998). Multiple Lyapunov functions and other analysis tools for switched and hybrid systems. IEEE Transactions on Automatic Control, 43(4), 475–482.
[2]. F. Gao, S. Bozhko, G. Asher, P. Wheeler and C. Patel, "An Improved Voltage Compensation Approach in a Droop-Controlled DC Power System for the More Electric Aircraft," in IEEE Transactions on Power Electronics, vol. 31, no. 10, pp. 7369-7383, Oct. 2016.
[3]. Alberto Cavallo, Giacomo Canciello, Beniamino Guida, "Supervised control of buck-boost converters for aeronautical applications", Automatica, Volume 83, 2017, Pages 73-80
[4]. M. K. AL-Nussairi, R. Bayindir, S. Padmanaban, L. Mihet-Popa, and P. Siano, "Constant power loads (cpl) with microgrids: Problem definition, stability analysis and compensation techniques," Energies, vol. 10, no. 10, 2017. [Online]. Available: http://www.mdpi.com/1996- 1073/10/10/1656A.
[5]. Cavallo, G. Canciello, B. Guida, "Supervisory control of DC-DC bidirectional converter for advanced aeronautic applications", International Journal of Robust and Nonlinear Control, 2017.

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

- 12 months: study and research period abroad.
- The University of Nottingham, Institute for Aerospace Technology, Faculty of Engineering, https://www.nottingham.ac.uk/engineering/departments/eee/index.aspx, University Park, Nottingham, NG7 2RD, UK.

Finanziato dall'Unione europea NextGenerationEU

GRANT N. 14

DAUSY

# D.M. 351/2022
# Ambito: Pubblica Amministrazione
# Tematica: "Fault Diagnosis and Security in Smart Cities"

**Research theme title:**

Fault Diagnosis and Security in Smart Cities

**Contacts:**

Prof. Alessandro Giua

e-mail: giua@unica.it

**Curriculum of DAUSY:**

C3 AS for monitoring and security

**Hosting University/Research Centre:**

University of Cagliari

**Department:**

Department of Electric and Electronic Engineering.

Via Marengo 2, 09123 Cagliari

https://unica.it/unica/it/dip_ingelettrica.page

**Prospective Supervisors:**

Prof. Alessandro Giua

**Description:**

A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business. From the perspective of automation and control, three key aspects are particularly relevant in this context. a) Smart cities are examples of large-scale distributed plants whose overall behaviour derives from the interaction of multiple agents and where monitoring and control can only be enforced in a decentralized fashion. b) Different heterogeneous services co-exist and interact with each other: this requires adopting very general models, capable of describing hybrid systems, characterized by both time-driven and event-driven dynamics. c) To ensure the secure behaviour of the overall systems while satisfying privacy concerns even in the presence of malicious attacks, it is necessary to implement and manage a high-level infrastructure capable of monitoring the overall behaviour of the system.

The objective of this thesis is that of addressing the issue of security and privacy in smart cities with a unifying approach that is not service-dependent but could be applied in different applicative domains. The reference paradigm that will be adopted for the modelling and analysis is that of cyber-physical systems, which integrate

sensing, computation, control and networking into physical objects and infrastructure, connecting them to the Internet and to each other.

The approach that will be adopted is that of extending to the more general setting of cyber-physical systems recent approaches, that have been developed by the discrete-event systems community to addresses problems of fault diagnosis, privacy analysis and enforcement, and resilience to cyber-attacks. The proposed methodologies will be developed in view of enabling their technology transfer toward a platform that could be used by local administrations to offer these new services to users.

Specific Information:

The candidate PhD student should have a master's or equivalent degree in the area of Information Engineering, with a good background in Control Systems.

References:

[1]. O. Bubelíny, M. Kubina, M. Varmus, "Railway Stations as Part of Mobility in the Smart City Concept," Transportation Research Procedia, Vol. 53, pp. 274-281, 2021.
[2]. C.G. Cassandras, "Smart Cities as Cyber-Physical Social Systems," Engineering, Vol. 2, No. 2, pp. 156-158, 2016.
[3]. European Commission, "Smart cities: using technological solutions to improve the management and efficiency of the urban environment," https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en
[4]. Y.H. Hu, Z.Y. Ma, Z.W. Li, A. Giua, "Diagnosability enforcement in labeled Petri nets using supervisory control", Automatica, Vol. 131, 2021.
[5]. S. Rani, A. Kataria, M. Chauhan, P. Rattan, R, Kumar, A.K. Sivaraman, "Security and Privacy Challenges in the Deployment of Cyber-Physical Systems in Smart City Applications: State-of-Art Work," Materials Today: Proceedings, 2022.
[6]. R. Su, "Supervisor synthesis to thwart cyberattacks with bounded sensor reading alterations," Automatica, Vol. 94, pp. 35-44, 2018.
[7]. Y. Tong, Y.C. Wang, A. Giua, "A Polynomial Approach to Verifying the Existence of A Threatening Sensor Attacker," IEEE Control Systems Letters. March 2022.
[8]. J. Zaytoon, S. Lafortune, "Overview of fault diagnosis methods for Discrete Event Systems," Annual Reviews in Control, Vol. 37, No. 2, pp. 308-320, 2013.
[9]. Q. Zhang, C. Seatzu, Z.W Li, A. Giua, "Joint State Estimation Under Attack of Discrete Event Systems," IEEE Access, Vol. 9, pp. 168068 - 168079, 2021.

Type of scholarship:

DM 351/2022 – Project on Public Administration

Study and research period outside the Hosting Institution:

- Period of study and research at a Public Administration: 6 months. ARST – Trasporti Regionali della Sardegna s.p.a. (sole shareholder: Autonomous Region of Sardinia), via Posada 8/10, 09122 Cagliari. http://www.arst.sardegna.it
- Period of study and research abroad: 6 months. Prof. Christos G. Cassandras, Division of Systems Engineering, Boston University, Boston. Massachusetts, USA. https://www.bu.edu/eng/departments/se

## GRANT N. 15

Finanziato dall'Unione europea NextGenerationEU

DAUSY

MUR

D.M. 351/2022
Ambito: PNRR
Tematica: "Distributed multi-object estimation for cooperative autonomous systems"

**Research theme title:**

Distributed multi-object estimation for cooperative autonomous systems

**Contacts:**

Luigi Chisci

e-mail: luigi.chisci@unifi.it

Giorgio Battistelli

e-mail: giorgio.battistelli@unifi.it

**Curriculum of DAUSY:**

C3 AS for monitoring and security

**Hosting University/Research Centre**

Università degli Studi di Firenze, Italy

**Department:**

Department of Information Engineering (DINFO)

Via Santa Marta 3, 50139 Firenze – Italy

https://www.dinfo.unifi.it

**Prospective Supervisors:**

Luigi Chisci (luigi.chisci@unifi.it)

Giorgio Battistelli (giorgio.battistelli@unifi.it)

**Description:**

In the context of autonomus navigation systems, it is fundamental that each mobile agent (e.g., ground vehicle, drone or underwater autonomous vehicle) be capable to self-localize and, simultaneously, build a map of the surrounding environment, possibly exploiting cooperation among the agents. This task is a challenging one, with many open research issues, also in view of various practical difficulties such as, for instance, the finite resolution and limited field-of-view of the sensors, the non-point-like nature of some (extended) objects of interest, the possible occurrence of several types of failures in the inter-agent communication including the ones due to cyber-attacks. A possible methodological approach to the above multi-object estimation task, to be investigated in this project, is the random finite set approach which aims to jointly: (1) detect objects present in the scene; (2) estimate their number and, for each object, kinematic state and geometrical shape; (3) identify, possibly with the aid of machine learning techniques, the type of each object. From a theoretical viewpoint, the work will focus on distributed fusion of multi-object information from multiple sources (agents) explicitly accounting for the different agents fields-of-view and presence of extended objects. The work will

also develop efficient distributed multi-object estimation algorithms for cooperative autonomous agents and assess their effectiveness in realistic simulation scenarios as well as in challenging real-world case-studies.

Specific Information:

Applicants must hold a Master degree, preferably but not necessarily in Engineering, with a good background in dynamical systems, probability, statistics and estimation. Proficiency in both spoken and written English is required. Good programming skills are also required.

References:

[1]. R. Mahler: *Statistical multisource multitarget information fusion*, Artech House, 2007.
[2]. R. Mahler: *Advances in statistical multisource multitarget information fusion,* Artech House, 2014.
[3]. S. Thrun, F. Burgard, D. Fox: *Probabilistic robotics*, MIT Press, 2006.
[4]. L. Gao, G. Battistelli, L. Chisci: Random-finite-set-based distributed multirobot SLAM, *IEEE Trans. on Robotics,* vol. 36, n. 6, pp. 1758-1777, 2020.
[5]. B. Wang, S Li, G. Battistelli, L. Chisci, W. Yi: Multi-agent fusion with different limited fields-of-view, *IEEE Trans. on Signal Processing*, vol. 70, pp. 1560-1575, 2022.

Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

Study and research period outside the Hosting Institution:

Minimum 6, maximum 12 months of the study and research period will be carried out abroad at the following institution:

Chalmers University of Technology, Göteborg, Sweden

https://www.chalmers.se/en/departments/e2/Pages/default.aspx

Finanziato dall'Unione europea
NextGenerationEU

GRANT N. 16

DAUSY

D.M. 351/2022

Ambito: PNRR
Tematica: “Robust control of traffic networks with heterogenous vehicles”

**Research theme title:**

Robust control of traffic networks with heterogenous vehicles

**Contacts:**

Prof. Simona Sacone

e-mail: simona.sacone@unige.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Genova, Italy

**Department:**

Department of Informatics, Bioengineering, Robotics and Systems Engineering

Via Opera Pia 13, 16145 Genova, Italy

www.dibris.unige.it

**Prospective Supervisors:**

Prof. Simona Sacone (simona.sacone@unige.it)

Prof. Roberto Sacile (roberto.sacile@unige.it)

**Description:**

The presence of different types of vehicles (traditional vehicles, partially or fully automated and connected vehicles, electric vehicles) in traffic networks is nowadays becoming a reality which poses the challenge of designing new modelling and control frameworks. The traditional modelling methods that have been developed in the last decades are no more adequate to traffic flows in which such heterogeneous vehicles have to coexist. On the other hand, innovative modelling techniques need suitable calibration which is not yet possible since real measurements about such a kind of process are not available due to very low or even null penetration rate of those new vehicle categories in current networks. This makes it necessary to design optimization and control techniques in which several modelling uncertainties are present and must be effectively tackled. The present research project addresses this need by adopting robust optimization and

control techniques in which some features of new flows of not traditional vehicles are considered as model uncertainties.

## Specific Information:

Applicants must hold a Master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., modelling, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. D. Bertsimas, D. B. Brown, C, Caramanis, "Theory and Applications of Robust Optimization", SIAM Review, 53 (3), 2011

[2]. T. Tettamanti, T. Luspay, B. Kulcsár, T. Péni and I. Varga, "Robust Control for Urban Road Traffic Networks," in *IEEE Transactions on Intelligent Transportation Systems*, 15 (1), pp. 385-398, 2014

[3]. Ferrara, S. Sacone, S. Siri, Freeway Traffic Modelling and Control, In: Advances in Industrial Control, Springer, DOI:10.1007/978-3-319-75961-6 - ISBN:978-3-319-75961-6, pp.1-311, 2018

[4]. D. Chen, D. Sun, D., H. Liu, "Robust control for cooperative driving system of heterogeneous vehicles with parameter uncertainties and communication constraints in the vicinity of traffic signals", Nonlinear Dynamics, 99, pp.1659–1674, 2020

[5]. C. Pasquale, S. Sacone, S. Siri, A. Ferrara, "Hierarchical Centralized/Decentralized Event-Triggered Control of Multi-Class Traffic Networks", IEEE Transactions on Control Systems Technology, 29 (4), pp. 1549–1564, 2021

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

Study and research period abroad:

- period length: 6 months;
- Hosting institution:
  - University of Technology of Compiegne, Heudiasyc Lab, UMR CNRS 7253 - 57 avenue de Landshut, COMPIEGNE CEDEX 60203 https://www.hds.utc.fr/

Finanziato dall'Unione europea NextGenerationEU

MUR

# GRANT N. 17

# DAUSY

## D.M. 351/2022

## Ambito: PNRR
## Tematica: "Exploiting Predictive capabilities in motion control for autonomous vehicles operating in crowded environments"

**Research theme title:**

Exploiting Predictive capabilities in motion control for autonomous vehicles operating in crowded environments

**Contacts:**

Prof. Laura Giarré

e-mail: laura.giarre@unimore.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Modena and Reggio Emilia

**Department:**

Department of Engineering 'Enzo Ferrari'

https://www.ingmo.unimore.it/site/en/home.html

**Prospective Supervisors:**

Prof. Laura Giarrè (laura.giarre@unimore.it)

Prof. Paolo Falcone (falcone@unimore.it)

**Description:**

The scientific theme will be the development of learning-based, predictive motion planning and control algorithms for autonomous vehicles operating with safety guarantees in complex and highly dynamic environments. Compared to the state-of-the-art algorithms, the idea is to enable persistent safety guarantees by interwinding learning, prediction and control tools. This objective will be achieved by imposing some property to the learning-based prediction tools and by introducing ad-doc safety set constraints. Particular attention to assisted autonomous vehicle operating in crowded environment for people with impairment, by exploiting well known techniques of autonomous driving. Prediction and learning are the enabling key of the entire project. Designing safety and smoothness requirements for a mobile vehicle operating in a crowded environment is a challenging task. This design problem is well-known in autonomous driving, where the

balance between safety and user's acceptance are of primary importance, but low cost sensors and acceptability need to be exploited when designed assisting vehicles.

The challenges in controlling the motion of such vehicles are

1) safely interacting with the user and 2) safely interacting with the surrounding crowd.

In particular, the vehicle should avoid maneuvers that can lead to a collision with the user, a tether drop or sudden change in direction that may undermine the user's confidence. At the same time the vehicle should not collide with the surrounding environment and, in particular, with the crowd therein.

The hypothesis underlying this research activity is that, in order to enable a safe yet smooth operation, the motion should be planned by anticipating the behavior of the surrounding crowd and the user. For this reason, we will approach the motion planning and control problem by resorting to predictive approaches, which rely on tools that learn from data and predict the behavior of the surrounding crowd and the users. Tools for the localization and navigation will serve the assistive vehicle for people affected by impairment.

Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., learning, optimization, and control). Solid mathematical and coding skills are welcome. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

References:

[1]. Batkovic, I., Ali, M., Falcone, P., & Zanon, M. Safe trajectory tracking in uncertain environments. arXiv preprint arXiv:2001.11602, 2020.
[2]. Batkovic, I., Rosolia, U., Zanon, M., & Falcone, P. A robust scenario MPC approach for uncertain multi-modal obstacles. IEEE Control Systems Letters, 5(3), 2020.
[3]. A. Toytziaridis, P. Falcone, and J. Sjöberg, "A data-driven markovian framework for multi-agent pedestrian collision risk prediction," IEEE Intell. Transp. Syst. Conf., 2019.
[4]. Adelberger, Daniel; Giarré, Laura; Ohtsuka, Toshiyuki; Luigi del, Re. Optimal Plug-and-Control of Unknown Nonlinear Systems In: EUROPEAN JOURNAL OF CONTROL. - ISSN 0947-3580. 2022.
[5]. Lo Valvo A, Croce D, Garlisi D, Giuliano F, Giarré L, Tinnirello I. A Navigation and Augmented Reality System for Visually Impaired People. Sensors.; 21(9):3061, 2020.
[6]. H. C. Wang, R. K. Katzschmann, S. Teng, B. Araki, L. Giarré and D. Rus, "Enabling independent navigation for visually impaired people through a wearable vision-based feedback system," 2017 IEEE International Conference on Robotics and Automation, 2017.
[7]. D. Croce, L. Giarré, F. Pascucci, I. Tinnirello, G. Galioto, D. Garlisi, A.Lo Valvo An Indoor and Outdoor Navigation System for Visually Impaired People, IEEE Access 7, 170406-170418, 2019.
[8]. Lu CL, Liu ZY, Huang JT, Huang CI, Wang BH, Chen Y, Wu NH, Wang HC, Giarré L, Kuo PY. Assistive Navigation Using Deep Reinforcement Learning Guiding Robot With UWB/Voice Beacons and Semantic Feedbacks for Blind and Visually Impaired People. Front Robot AI. 2021 Jun 22;8:654132
[9]. Gianluigi Pillonetto, Tianshi Chen, Alessandro Chiuso, Giuseppe De Nicolao, Lennart Ljung. Regularized System Identification: Learning Dynamic Models from Data, Communications and Control Engineering Series, Springer, 2022.

Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

Finanziato dall'Unione europea NextGenerationEU

Study and research period outside the Hosting Institution:

1. Study and research period abroad:

- period length: 8 months;
- Hosting institution: Chalmers University of Technology
- https://www.chalmers.se/en/Pages/default.aspx
- E-412 96 GOTHENBURG, SWEDEN - PHONE: +46 (0)31-772 10 00

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 18

# DAUSY

## D.M. 351/2022
## Ambito: PNRR
## Tematica: "Advanced modeling and control of complex systems

**Research theme title:**

Advanced modeling and control of complex systems

**Contacts:**

Prof. Luca Schenato

e-mail: l.schenato@unipd.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Padova

**Department:**

Dipartimento di Ingegneria dell'Informazione

Via Gradenigo 6/b, Padova

https://www.dei.unipd.it/

**Prospective Supervisors:**

Luca Schenato (l.schenato@unipd.it )

Maria Elena Valcher (mariaelena.valcher@unipd.it )

Gian Antonio Susto (gianantonio.susto@unipd.it )

**Description:**

The project embraces the mission of the PNRR where control systems play a fundamental and pervasive role in the digital transition of society. In particular, the project aims to develop advanced modeling, estimation, control and optimization methodologies for complex systems using techniques such as distributed optimization, predictive control, multi-agent algorithms, data-driven machine learning approaches and social networks. Currently, the methodologies of control systems used in real applications are typically based on centralized architectures: with the advent of the Internet of Things, smart environments and factories, devices as well humans-in-the-loop, now have the ability to distribute the intelligent component in more sophisticated architectures, posing new challenges. The project aims to develop innovative control methodologies aimed at improving the scalability, robustness and adoption of such solutions.

**Specific Information:**

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., machine learning, optimization, systems theory, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

## References:

[1]. Kyoung-Dae Kim, P. R. Kumar, "Cyber-Physical Systems: A Perspective at the Centennial", vol. 100, page 1287-1308, 2012
[2]. Giacomo Baggio, Danielle S. Bassett & Fabio Pasqualetti, "Data-driven control of complex networks", *Nature Communications* volume 12, Article number: 1429, 2021
[3]. GA Susto, A Schirru, S Pampuri, S McLoone, A Beghi, "Machine learning for predictive maintenance: A multiple classifier approach" IEEE transactions on industrial informatics 11 (3), 812-820, 2015
[4]. L Ballotta, L Schenato, L Carlone, "Computation-communication trade-offs and sensor selection in real-time estimation for processing networks" IEEE Transactions on Network Science and Engineering 7 (4), 2952-2965, 2020

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

- period length: 9 months;
- Hosting institution:
  - UC Santa Barbara - Department of Mechanical Engineering
  - Santa Barbara, CA, U.S.A.
  - https://www.me.ucsb.edu/

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 19

# DAUSY

## D.M. 351/2022
## Ambito: Pubblica Amministrazione
## Tematica: "Sensor network and data analysis to support decision and governance of complex systems"

**Research theme title:**

Sensor network and data analysis to support decision and governance of complex systems


**Contacts:**

Prof. Filippo D'Ippolito

e-mail: filippo.dippolito@unipa.it


**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

University of Palermo, Italy

**Department:**

Department of Engineering

Viale delle scienze,

90128 PALERMO - ITALY

**Prospective Supervisors:**

Prof. Antonino Sferlazza, (https://www.unipa.it/persone/docenti/s/antonino.sferlazza)

Prof. Filippo D'Ippolito, (https://www.unipa.it/persone/docenti/d/filippo.dippolito)

**Description:**

The effectiveness, efficiency and economy of public action depends on the degree of knowledge of complex systems that the public administration manages and governs, in particular in those situations in which public decision makers have to perform appropriate crisis management policies.

Often, these systems are distributed and have complex dynamics, with mixed signal with continuous and discrete time nature. To better understand and govern these complex systems, distributed sensor systems and a suitable intelligent decision support system have to be considered. Suitable observers may be designed in order to better understand the complex dynamics of these systems based on a sensor network, able to capture suitable information needed to characterize the system. Moreover, appropriate data analysis and machine learning strategies should be developed in order to realize optimal decision policies.

Regarding the system modeling, the hybrid dynamical systems constitute a suitable framework for representing physical systems that embed both continuous, discrete as well as event-based dynamics. For this reason, the PhD candidate will investigate the possibility to cast the above mentioned complex dynamics into the hybrid systems framework. This will constitute a solid methodological starting point to design observers and optimal decision policies.

The activity will make use of an IoTGIS platform, developed in the laboratory of the hosting University, which is an IoT system connected to a GIS system, in a WEB framework suitable to acquire georeferenced measurements, through electronic devices, and allow to process and visualize them in a suitable way.

Specific Information:

The PhD candidates must hold a master's degree, preferably in Engineering, with a good background in control systems and data analysis. Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. Applicants should have strong motivation toward theoretical analysis and synthesis of automatic control systems.

References:

[1]. Garraffa, G., Sferlazza, A., D'Ippolito, F., Alonge, F., *Localization Based on Parallel Robots Kinematics As an Alternative to Trilateration,* (2022) IEEE Transactions on Industrial Electronics, 69(1), pp.999-1010.
[2]. La Guardia, M., D'Ippolito, F., Cellura, M., *Construction of a webgis tool based on a gis semiautomated processing for the localization of p2g plants in Sicily (Italy),* (2021) ISPRS International Journal of Geo-Information, 10(10), art. no.671.
[3]. Sferlazza, A., Tarbouriech, S., Zaccarian, L. *State observer with Round-Robin aperiodic sampled measurements with jitter,* (2021) Automatica, 129, art. no. 109573.
[4]. Sferlazza, A., Sophie Tarbouriech, S., Zaccarian L., *Time-varying sampled-data observer with asynchronous measurements,* (2018) IEEE Transactions on Automatic Control 64.2, pp. 869-876.
[5]. Alonge, F., D'Ippolito, F., Garraffa, G., Sferlazza, A., *A hybrid observer for localization of mobile vehicles with asynchronous measurements*, (2019) Asian Journal of Control 21.4, pp. 1506-1521.
[6]. F., D'Ippolito, F., Garraffa, G., and Sferlazza, A. and Zaccarian, L., *Localization from inertial data and sporadic position measurements*, (2020) IFAC-PapersOnLine 53.2, pp. 5976-5981.

Type of scholarship:

DM 351/2022 – Project on Public Administration

Study and research period outside the Hosting Institution:

1. Study and research period abroad:
- period length: Minimum 6 months;
- Hosting institution:
  - LAAS-CNRS, 7 avenue du Colonel Roche, 31400 Toulouse, France
2. Study and research period in a Public Administration:
- period length: 6 months;
- Public Administration where such kind of systems are of potential interest:
  - AMAT Palermo S.p.A., Via Roccazzo, 77 - 90135 Palermo (joint-stock company with sole shareholder the Municipality of Palermo)
  - Provincial Health Authority of Palermo, Via Giacomo Cusmano, 24 – 90141 Palermo

Finanziato dall'Unione europea NextGenerationEU

DAUSY

MUR

# D.M. 351/2022
# Ambito: Pubblica Amministrazione
# Tematica: "Artificial Intelligence in Autonomous Robotic Service Fleet Management for the Smart Cities of the Future"

**Research theme title:**

Artificial Intelligence in Autonomous Robotic Service Fleet Management for the Smart Cities of the Future

**Contacts:**

Prof. Lorenzo Pollini

e-mail: lorenzo.pollini@unipi.it

**Curriculum of DAUSY:**

C3 - AS for Monitoring and Security

**Hosting University/Research Centre**

University of Pisa

**Department:**

Department of Information Engineering,

University of Pisa

Via G. Caruso 16 - 56122 - Pisa

Tel +39 050 2217511 - info@dii.unipi.it

PEC: ing.informazione@pec.unipi.it

Website: www.dii.unipi.it

**Prospective Supervisors:**

Prof. Lorenzo Pollini (lorenzo.pollini@unipi.it)

Prof. Riccardo Costanzi (riccardo.costanzi@unipi.it)

**Description:**

The aim of the training project is to lay the theoretical foundations for the automation of decision-making processes for autonomous vehicles and robots that will populate smart cities in the future. Public Administrations organize a large number of services, such as, for example, infrastructure maintenance, waste collection, cleaning of streets and common areas etc. and these services will be characterized by an ever-increasing level of automation. It is conceivable that many of the jobs carried out manually today will instead be carried out by automatic machines that will have to share spaces with human operators and citizens in

general. To this end, it is necessary to identify tools, based on artificial intelligence and innovative decision and control algorithms, which will allow public administrations to implement mission management logics for the autonomous vehicles that will make up their service fleet. The goal is to equip public administrations with tools that make delegation to the machines of the necessary daily city care activities more autonomous, reliable and effective, including strategic fleet management, monitoring of operations, automatic management of emergencies and contingencies, automatic reporting generation and intelligent troubleshooting.

### Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., machine learning, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

### References:

[1]. Kase Sue E., Hung Chou P., Krayzman Tomer, Hare James Z., Rinderspacher B. Christopher, Su Simon M., The Future of Collaborative Human-Artificial Intelligence Decision-Making for Mission Planning, Frontiers in Psychology , Vol. 13, 20222, doi: 10.3389/fpsyg.2022.850628
[2]. Lefevre K., Arora C., Lee K., Zaslavsky A., Bouadjenek M.R., Hassani A., Razzak I., ModelOps for enhanced decision-making and governance in emergency control rooms, (2022) Environment Systems and Decisions, DOI: 10.1007/s10669-022-09855-1
[3]. Goecks V.G., Waytowich N., Asher D.E., Jun Park S., Mittrick M., Richardson J., Vindiola M., Logie A., Dennison M., Trout T., Narayanan P., Kott A., On games and simulators as a platform for development of artificial intelligence for command and control, (2022) Journal of Defense Modeling and Simulation, DOI: 10.1177/15485129221083278
[4]. Ranasinghe K., Sabatini R., Gardi A., Bijjahalli S., Kapoor R., Fahey T., Thangavel K., Advances in Integrated System Health Management for mission-essential and safety-critical aerospace applications
[5]. (2022) Progress in Aerospace Sciences, 128, art. no. 100758, DOI: 10.1016/j.paerosci.2021.100758
[6]. Mercado J.E., Rupp M.A., Chen J.Y.C., Barnes M.J., Barber D., Procci K., Intelligent Agent Transparency in Human-Agent Teaming for Multi-UxV Management, (2016) Human Factors, 58 (3), pp. 401 - 415, DOI: 10.1177/0018720815621206
[7]. Zhai Z., Martínez J.F., Beltran V., Martínez N.L., Decision support systems for agriculture 4.0: Survey and challenges (2020) Computers and Electronics in Agriculture, 170, art. no. 105256, DOI: 10.1016/j.compag.2020.105256
[8]. Junejo K.N., Goh J., Behaviour-based attack detection and classification in cyber physical systems using machine learning, (2016) CPSS 2016 - Proceedings of the 2nd ACM International Workshop on Cyber-Physical System Security, Co-located with Asia CCS 2016, pp. 34 - 43, DOI: 10.1145/2899015.2899016

### Type of scholarship:

DM 351/2022 – Project on Public Administration

### Study and research period outside the Hosting Institution:

Duration of the study and research period at the company or research center or Public Administration: 6 to 12 months

Name of receiving company or public administration: to be defined

Duration of the study and research period abroad: 6 to 18 months

Name of receiving institution: to be defined

GRANT N. 21

DAUSY

D.M. 351/2022

Ambito: PNRR
Tematica: “Advanced control allocation techniques for large multi-agent systems and large sensors/actuators networks”

**Research theme title:**

Advanced control allocation techniques for large multi-agent systems and large sensors/actuators networks

**Contacts:**

Prof. Sergio Galeani

e-mail: sergio.galeani@uniroma2.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

University of Rome, Tor Vergata, Italy

**Department:**

Department of Civil Engineering and Computer Science Engineering

Via Politecnico 1, 00133 Roma – Italy

http://dicii.uniroma2.it

**Prospective Supervisors:**

Prof. Sergio Galeani

Prof. Laura Menini

**Description:**

The ever-increasing requests in terms of performance, flexibility and resilience both in autonomous production environments (under the Industry 4.0 paradigm) and in more general automation and robotics scenarios (such as search-and-rescue missions, renewable energy production involving micro-grids, precision agriculture, water distribution networks, and so on) have motivated a strong interest in the development of large-scale, multi-agent systems, as well as of large-scale networks of sensors and actuators. In many applications, the key element to achieve challenging objectives relies critically on the ability to coordinate such multi-agent systems in an optimal but flexible way. An additional ingredient adding complexity to the task is given by the fact that the operating environment is frequently unknown (at least up to some degree), and then the devised strategies must strike a balance between exploiting a priori given models and leveraging on data measured in real time.

The goal of this project is to address the problems arising in large multi-agent systems and large sensor/actuator networks by developing innovative extensions of dynamic control allocation (DCA). Given an existing control loop equipped with a set of redundant actuators (that is, whose number exceeds the number of controlled outputs), DCA is an add-on compensation technique which can optimize the actuation demand without modifying the output response of the original control loop; the optimization criterion is usually in the form of a general Lagrange functional (and then tools from optimal control theory are involved) and can be changed in real time (thus providing flexibility in terms of goals). In order to address the considered applications, several challenging extensions have to be developed, including a dual theory for dealing with redundant sensors, and a data-driven identification and optimization (requiring the use of machine and reinforcement learning). Cross-fertilization with the redundancy resolution literature in robotics will also be considered, which might also lead to novel ideas for the control of extremely over-actuated systems such as soft/flexible robots.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., control theory, optimization and machine learning), and solid mathematical and coding skills. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking challenging research activities involving theoretical formulation and analysis of novel problems, their solution by properly designed and formally proven strategies, and the validation of the latter on realistic simulation or experimental scenarios.

## References:

[1]. T. A. Johansen, T. I. Fossen, Control allocation - A survey, Automatica, Vol. 49, Issue 5, 2013, pp. 1087-1103, https://doi.org/10.1016/j.automatica.2013.01.035.
[2]. L. Zaccarian, Dynamic allocation for input redundant control systems, Automatica, Vol. 45, Issue 6, 2009, pp. 1431-1438, https://doi.org/10.1016/j.automatica.2009.01.013.
[3]. S. Galeani, A. Serrani, G. Varano, L. Zaccarian, On input allocation-based regulation for linear over-actuated systems, Automatica, Vol. 52, 2015, pp. 346-354, https://doi.org/10.1016/j.automatica.2014.10.112
[4]. A. Cristofaro, S. Galeani, "Output invisible control allocation with steady-state input optimization for weakly redundant plants," 53rd IEEE Conference on Decision and Control, 2014, pp. 4246-4253, doi: 10.1109/CDC.2014.7040051
[5]. S. Galeani, S. Pettinari, "On dynamic input allocation for fat plants subject to multi-sinusoidal exogenous inputs," 53rd IEEE Conference on Decision and Control, 2014, pp. 2396-2403, doi: 10.1109/CDC.2014.7039754
[6]. C. Della Santina. C. Duriez, D. Rus, "Model based control of soft robots: A survey of the state of the art and open challenges," arXiv:2110.01358, Oct. 2021. https://doi.org/10.48550/arXiv.2110.01358
[7]. F. Flacco, A. De Luca, O. Khatib, "Control of redundant robots under hard joint constraints: Saturation in the null space," IEEE Trans. on Robotics, Vol. 31, no. 3, pp. 637-654, 2015. DOI:10.1109/TRO.2015.2418582
[8]. F. Flacco, A. De Luca, "Unilateral constraints in the Reverse Priority redundancy resolution method," Proc. 2015 IEEE/RSJ Int. Conf on Intelligent Robots and Systems, pp. 2564-2571, 2015. DOI:10.1109/IROS.2015.7353726

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

Study and research period abroad:

- period length: 6 months;
- Hosting institution:
  - Ohio State University - Department of Electrical and Computer Engineering, 2015 Neil Ave, Columbus, OH 43210-1210 – USA (https://engineering.osu.edu)

➢ Note that the above period length and hosting institution are the ones that currently appear most suitable for the devised PhD project, but changes are possible: in particular, conditioned on the results of the PhD student's research activity, an extension of the period (up to 18 months) and a different hosting institution might also be considered, if a more profitable collaboration or a better match with research topics is devised.

Finanziato dall'Unione europea
NextGenerationEU

GRANT N. 22

DAUSY

D.M. 351/2022

Ambito: PNRR
Tematica: “Mathematical theory for control and optimization of evolutionary phenomena”

**Research theme title:**

Mathematical theory for control and optimization of evolutionary phenomena.

**Contacts:**

Prof. Andrea Pinamonti

e-mail: andrea.pinamonti@unitn.it

Prof. Fabio Bagagiolo

e-mail: fabio.bagagiolo@unitn.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

University of Trento, Italy

**Department:**

Department of Mathematics,

Via Sommarive, 14, 38123 Povo-Trento, Italy

https://www.maths.unitn.it/en

**Prospective Supervisors:**

Prof. Andrea Pinamonti (https://webapps.unitn.it/du/it/Persona/PER0015797)

Prof. Fabio Bagagiolo (https://bagagiolo.maths.unitn.it/index.html/)

**Description:**

The goal of the present project is the study, the application and the development of mathematical theories for control and optimization of evolutionary phenomena motivated by engineering and real-life applications.

The typical differential equations for the evolution of the system under study can be often seen as describing evolution in an abstract environment such as functional and/or metric spaces. Such a point of view brings to important questions of mathematical nature which are also often enlightening for the possible applications to the motivating real-life models. Problems such as controllability, optimal control, optimal transport, motion planning will be the main examples of sources of mathematical questions and motivating applications.

The doctoral student will be asked to investigate, from a mathematical point of view, problems among the following (not exhaustive) list:

controllability, optimal control and/or dynamic games for

multi-agent systems (both in Euclidean setting as well as on networks, and with possibly infinitely many agents);

hybrid systems (continuous and discrete systems, in particular dynamic programming and Hamilton-Jacobi theory);

systems with hysteresis (evolving systems with suitable dependence on the past history of the evolution itself);

geometric control theory with particular emphasis to the applications to nonholonomic path planning of mobile robots.

The strong interaction with scientists of more applicative fields will be also a valuable point of the research activity of the student.

## Specific Information:

Applicants must hold a master's degree, preferably in Mathematics, with a good background in some of the relevant areas of interest and of the related mathematical tools, such as: control, optimal control, optimal transport, calculus of variations, differential equations theory, functional analysis, analysis on metric spaces, measure theory. Numerical methods expertise will be also welcome.

Proficiency in both spoken and written English is required.

The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and possible applications.

## References:

[1]. Bardi M., Capuzzo Dolcetta I.: Optimal Control and Viscosity Solutions of Hamilton-Jacobi-Bellman Equations. Birkhauser, 1997.
[2]. Cardaliaguet, P.: Notes on Mean Field Games. Lecture notes (from P.-L. Lions' lectures at College de France), 2013.
[3]. Coron J.M.: Control and Nonlinearity, AMS, Providence, 2007.
[4]. Goebel R., Sanfelice R.G., and Teel A.R.: Hybrid Dynamical Systems: Modeling, Stability, and Robustness, Princeton University Press, Princeton, 2012.
[5]. Latombe J-C: Robot Motion Planning, Kluwer Academic Publishers, Boston, 1991.
[6]. Laumond J-P: Robot Motion Planning and Control, Lecture Notes in Control and Information Sciences, Vol. 229, Springer, 1998.

[7]. Reeds JA, Shepp LA, Optimal paths for a car that goes both forwards and backwards, Pacific Journal of Mathematics, 145, (1990), 367-393.
[8]. Sussmann HJ, Tang G: Shortest Paths For The Reeds-Shepp Car: A Worked Out Example Of The Use Of Geometric Techniques In Nonlinear Optimal Control, Department of Mathematics, Rutgers University, September, 1991, Report No.:SYCON-91-10.
[9]. Visintin A.: Differential Models of Hysteresis, Springer Verlag, Berlin, 1994.

**Type of scholarship:**

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

**Study and research period outside the Hosting Institution:**

LJLL - Laboratoire Jacques-Louis Lions, Sorbonne université

Boîte courrier 187, 4 place Jussieu, 75252 Paris Cedex 05 (France)

6 months

GRANT N. 23

DAUSY

D.M. 351/2022
Ambito: Transizioni Digitali e Ambientali
Tematica: “Shared-control framework for smart human-vehicle cooperation in the context of autonomous and assisted driving”

**Research theme title:**

Shared-control framework for smart human-vehicle cooperation in the context of autonomous and assisted driving

**Contacts:**

Francesco Biral

e-mail: Francesco.biral@unitn.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

University of Trento, Italy

**Department:**

Department of Industrial Engineering

Via Sommarive 9, I- 38123 Trento

https://www.dii.unitn.it

**Prospective Supervisors:**

Prof. Francesco Biral (francesco.biral@unitn.it)

Prof. Mauro Da Lio (mauro.dalio@unitn.it)

**Description:**

Road transport systems represent a significant fraction of both the energy used and the pollution produced worldwide. Driving support systems that help reduce the energy footprint of vehicles have been mainly investigated by trying to optimize vehicle maneuvers, i.e., the style of acceleration and deceleration over short time horizons. Cooperative systems that promise to optimize the tactical-strategic level and consequently harmonize the movement of vehicles will only be fully usable when most of the vehicles are cooperative. The ability to correctly predict the other road users behavior and support the driver in taking the best maneuver (i.e. safer and using less energy) is a key functionality of autonomous driving and driving assistance systems.

The goal of this project is to develop an autonomous driving framework, which is able to predict the future evolution of other vehicles in the scenario and suggest/support to the driver to execute the best maneuver for

the given context in term of safety and fuel consumption. Thus, one main challenges will be the capability of the system to learn the vehicle dynamic from everyday use to improve its control ability, and secondly, defining the algorithm to explore imaginary (unperceived) situations that might occur. Artificial intelligence can help generate probable conditions and recommend energy-saving (and safe) behaviors even when the danger is not actual but only hypothetical. This will reduce unexpected events, related emissions and wasted energy. A third main challenge is the definition of the shared-control framework that 'silently' continuously monitor the driver and support/correct him/her in a transparent way.

The algorithms will be developed and tested in a highly accurate driving simulator and on experimental self-driving research vehicles. Collaboration with automotive companies will be also expected.

Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., machine learning, vehicle dynamics, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian logistic company, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

References:

[1]. M. da Lio, R. Don`a, G. Papini, F. Biral, and H. Svensson, "A mental simulation approach for learning neural-network predictive control (in self-driving cars)," IEEE Access, vol. 8, pp. 192041–192064, 2020..
[2]. L. De Pascali, F. Biral, and S. Onori, "Aging-aware optimal energy management control for a parallel hybrid vehicle based on electrochemical-degradation dynamics," IEEE Transactions on Vehicular Technology, vol. 69, no. 10, pp. 10868–10878, 2020.
[3]. M. Piccinini, M. Larcher, E. Pagot, D. Piscini, L. Pasquato, and F. Biral, "A predictive neural hierarchical framework for on-line time-optimal motion planning and control of black-box vehicle models," Vehicle System Dynamics, vol. 0, no. 0, pp. 1–28, 2022.
[4]. G. Valenti, E. Pagot, L. De Pascali and F. Biral, "Battery Aging-Aware Online Optimal Control: An Energy Management System for Hybrid Electric Vehicles Supported by a Bio-Inspired Velocity Prediction," in IEEE Access, vol. 9, pp. 164394-164416, 2021, doi: 10.1109/ACCESS.2021.3134471.

Type of scholarship:

DM 351/2022 – Project on Digital and Green Transition

Study and research period outside the Hosting Institution:

Insert:

1. Study and research period abroad:
- period length: 6 months;
- Hosting institution:
  - Universität der Bundeswehr München
  - Werner-Heisenberg-Weg 39, 85577 Neubiberg, Germany
  - https://www.unibw.de/home-en
    https://www.unibw.de/ingmathe/vehicle-in-the-loop/automated-vehicle-in-the-loop

## GRANT N. 24

## DAUSY

Finanziato dall'Unione europea NextGenerationEU

# D.M. 351/2022
# Ambito: PNRR
# Tematica: "Model-based design for increasing reliability and safety of autonomous systems"

**Research theme title:**

Model-based design for increasing reliability and safety of autonomous systems

**Contacts:**

Prof. Sauro Longhi

e-mail sauro.longhi@univpm.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Università Politecnica delle Marche

**Department:**

Department of Information Engineering

Via Brecce Bianche 12

60131 Ancona, Italy

https://www.dii.univpm.it/

**Prospective Supervisors:**

Prof. Sauro Longhi (sauro.longhi@univpm.it)

**Description:**

Autonomous systems represent a key enabling technology for the digital transition. For a system to reach autonomy, it must be indeed capable of collecting and properly processing a large quantity of information, and possibly employ it to ensure its proper functioning as well as the safety of the people next to it. It is thus of utmost importance that unexpected internal problems, such as faults, can be discovered and quickly addressed before degenerating into a total system failure, which may cause both economical and human losses. For instance, an autonomous aerial vehicle experiencing a fault should be at least able to land in order to avoid a crash, or a faulty industrial robot should be at least able to stop before causing harm to a human operator. This may be achievable thanks to the information on the internal states of the system and on the environment in which it operates. Moreover, whenever such information is augmented by a model, fault diagnosis and fault-tolerant control techniques represent an effective way to increase the reliability and safety of the system. Starting from relevant models available in the literature, the PhD candidate will be required to investigate the state of the art on linear and nonlinear techniques for fault detection and diagnosis, as well as fault-tolerant control techniques, using both active and passive approaches. These techniques will be then validated in one or more application scenarios, which may include unmanned vehicles, mobile robots, industrial manipulators and intelligent machines in general.

## Specific Information:

Applicants must hold a Master's Degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., modelling, estimation, and control). Proficiency in both spoken and written English is required. Solid mathematical, coding and teamwork skills are encouraged.

## References:

[1]. A. Monteriù, A. Freddi, S. Longhi (editors), "Fault Diagnosis and Fault-tolerant Control of Robotic and Autonomous Systems", IET (UK), July 2020.
[2]. R. Felicetti, A. Baldini, A. Freddi, S. Longhi, A. Monteriù, "Actuator Fault Tolerant Control of Variable Pitch Quadrotor Vehicles," in IFAC-PapersOnLine - 21st IFAC World Congress, vol. 53, no. 2, pp. 4095 – 4102, Berlin, Germany, Jul. 2020.
[3]. Baldini, R. Felicetti, A. Freddi, S. Longhi, and A. Monteriù, "Actuator Fault-Tolerant Control Architecture for Multirotor Vehicles in Presence of Disturbances," Journal of Intelligent & Robotic Systems, Springer Nature (Switzerland), vol. 99, pp. 859–874, Feb. 2020.
[4]. A. Baldini, L. Ciabattoni, R. Felicetti, F. Ferracuti, A. Freddi, and A. Monteriù, "Dynamic surface fault tolerant control for underwater remotely operated vehicles," ISA Transactions, Elsevier (Netherlands), vol. 78, pp. 10–20, Jul. 2018 (first online 1 March 2018).
[5]. S. Li, J. Yang, W. Chen, and X. Chen, Disturbance Observer-Based Control: Methods and Applications, ser. Disturbance Observer-based Control: Methods and Applications. CRC Press, Taylor & Francis Group, 2017.
[6]. Gao, Zhiwei, Carlo Cecati, and Steven X. Ding. "A survey of fault diagnosis and fault-tolerant techniques—Part I: Fault diagnosis with model-based and signal-based approaches." IEEE transactions on industrial electronics 62.6 (2015): 3757-3767.
[7]. A. Lanzon, A. Freddi, and S. Longhi, "Flight Control of a Quadrotor Vehicle Subsequent to a Rotor Failure," Journal of Guidance, Control and Dynamics, AIAA (United States of America), vol. 37, no. 2, pp. 580–591, Mar. 2014 (first online 12 February 2014).

## Type of scholarship:

DM 351/2022 – Project on PNRR (Italy's Recovery and Resilience Plan)

## Study and research period outside the Hosting Institution:

- Duration: 6 to 18 months;
- Foreign Hosting Institution:

Department of Mechanical Engineering - Eindhoven University of Technology
https://www.tue.nl/en/

GRANT N. 25

DAUSY

D.M. 352/2022
Co-finanziata da: ICAM S.r.l.
Tematica: “Decision and control techniques for collaborative robotics in automated warehouses”

**Research theme title:**

Decision and control techniques for collaborative robotics in automated warehouses

**Contacts:**

Prof. Mariagrazia Dotoli

email: mariagrazia.dotoli@poliba.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Polytechnic of Bari, Italy

**Department:**

Department of Electrical and Information Engineering

via Orabona 4, 70125 Bari - Italy

https://deipoliba.azurewebsites.net/en/department/

**Prospective Supervisors:**

Prof. Mariagrazia Dotoli (http://dclab.poliba.it/people/mariagrazia-dotoli/)

Dr. Raffaele Carli (http://dclab.poliba.it/people/raffaele-carli/)

**Description:**

The Fourth Industrial Revolution, also known as Industry 4.0, is reshaping the way individuals live and work while providing a substantial influence on the manufacturing scenario. One of the key enabling technologies that has made Industry 4.0 a concrete reality is without doubt collaborative robotics, which is also evolving as a fundamental pillar of the next revolution, the so-called Industry 5.0 that reinserts proactively humans back into the automation chain, allowing operators and robots to work significantly more closely together. In contrast to robots that predominantly work independently from humans and often reside in a cage, collaborative robots (cobots) co-exist in the same environment together with humans, without renouncing to safety or efficiency.

The goal of this project is to develop innovative decision and control techniques for human robot collaboration (HRC) by ensuring the best trade-off between safety and ergonomics for the operator and efficiency for the industrial process. In particular, this project will focus on the automation of production processes in the context of internal logistics and therefore in industrial warehouses, not yet fully automated, in which there are significant margins for developing innovative solutions aimed at increasing productivity and profitability, with the simplification, planning, and scheduling of robot and operator activities in accordance with safety and ergonomics requirements.

The research will be applied to real logistic scenarios provided by ICAM Srl, which is an Italian company specialized in automated solutions for automated warehousing and Logistics 4.0.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., robotics, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian logistic company, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. Proia, S., Carli, R., Cavone, G., & Dotoli, M. (2021). Control Techniques for Safe, Ergonomic, and Efficient Human-Robot Collaboration in the Digital Industry: A Survey. IEEE Transactions on Automation Science and Engineering.
[2]. Proia, S., Cavone, G., Carli, R., & Dotoli, M. (2022). A Trajectory Planning Optimization Approach for a Safe and Ergonomic Human-Robot Collaboration In 2021 IEEE 18th International Conference on Automation Science and Engineering (CASE). IEEE.
[3]. Cherubini, A., Passama, R., Crosnier, A., Lasnier, A., & Fraisse, P. (2016). Collaborative manufacturing with physical human–robot interaction. Robotics and Computer-Integrated Manufacturing, 40, 1-13.
[4]. Zanchettin, A. M., Ceriani, N. M., Rocco, P., Ding, H., & Matthias, B. (2015). Safety in human-robot collaborative manufacturing environments: Metrics and control. IEEE Transactions on Automation Science and Engineering, 13(2), 882-893.
[5]. Lucci, N., Lacevic, B., Zanchettin, A. M., & Rocco, P. (2020). Combining speed and separation monitoring with power and force limiting for safe collaborative robotics applications. IEEE Robotics and Automation Letters, 5(4), 6121-6128.
[6]. Ferraguti, F., Villa, R., Landi, C. T., Zanchettin, A. M., Rocco, P., & Secchi, C. (2020). A unified architecture for physical and ergonomic human–robot collaboration. Robotica, 38(4), 669-683.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

1. Study and research period at the company:
   - period length: 12 months;
   - Company:
     - ICAM srl, S.P. 237 delle Grotte, Putignano BA 70017 Italy (https://www.icamonline.eu/en/)
2. Study and research period abroad:
   - period length: 6 months;

- Hosting institution:
  - Rutgers, The State University of New Jersey, Department of Mechanical & Aerospace Engineering, 98 Brett Road, Piscataway, NJ 08854 – USA (https://mae.rutgers.edu/jingang-yi - https://mae.rutgers.edu/)

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 26

# DAUSY

## D.M. 352/2022
## Co-finanziata da: ICAM S.r.l.
## Tematica: “Decision and control techniques for fleets of cooperative robots in automated warehouses”

**Research theme title:**

Decision and control techniques for fleets of cooperative robots in automated warehouses

**Contacts:**

Prof. Mariagrazia Dotoli

e-mail: mariagrazia.dotoli@poliba.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Polytechnic of Bari

**Department:**

Department of Electrical and Information Engineering

via Orabona 4, 70125 Bari - Italy

https://deipoliba.azurewebsites.net/en/department/

**Prospective Supervisors:**

Prof. Mariagrazia Dotoli (http://dclab.poliba.it/people/mariagrazia-dotoli/)

Dr. Raffaele Carli (http://dclab.poliba.it/people/raffaele-carli/)

**Description:**

In the Industry 4.0 paradigm, which aims at establishing intelligent, interoperable, and autonomous production environments, the problem of planning, management, and control fleets of Automated Guided Vehicles (AGVs) and/or Rail Guided Vehicles (RGVs) is receiving enormous interest for an efficient and sustainable logistics. Traffic management of cooperating robots for handling loads in automated warehouses of smart factories and distribution centers is indeed a significant challenge for the real-time control aimed at predicting and preventing congestion while ensuring an increase in productivity and business flexibility.

The goal of this project is to improve the performance of automated warehouses by developing scheduling algorithms for the activities carried out by the multi-robot system, together with path-planning, collision

avoidance, driving, navigation, and control algorithms. In particular, conventional task allocation and path planning algorithms will be merged into machine learning frameworks with the aim of controlling AGVs' and/or RGVs' fleets in real-time and scheduling their activities in an optimal way by collecting and managing a large amount of data obtained by several simulated and real-world industrial scenarios. Thus, the main challenges will lie in defining machine learning techniques -such as supervised learning (e.g., artificial neural networks, support vector machines), unsupervised learning (e.g., principal component analysis), reinforcement learning and deep learning (e.g., convolutional neural networks, restricted Boltzmann machine and auto-encoders)- aimed at predicting and preventing congestion in vehicular traffic. In order to improve the efficiency of AGVs and/or RGVs, maximize productivity, and minimize downtime, scheduling algorithms will be also developed based on the integration of data-driven methods with simulation, optimization, and optimal control techniques.

The research will be applied to real logistic scenarios provided by ICAM Srl, which is an Italian company specialized in automated solutions for automated warehousing and Logistics 4.0.

## Specific Information:

Applicants must hold a master's degree in Engineering, with a good background in relevant areas of interest (i.e., machine learning, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian logistic company, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. Angelopoulos, A., Michailidis, E. T., Nomikos, N., Trakadas, P., Hatziefremidis, A., Voliotis, S., & Zahariadis, T. (2019). Tackling faults in the industry 4.0 era—a survey of machine-learning solutions and key aspects. Sensors, 20(1), 109.
[2]. Lee, S., Kim, Y., Kahng, H., Lee, S. K., Chung, S., Cheong, T., ... & Kim, S. B. (2020). Intelligent traffic control for autonomous vehicle systems based on machine learning. Expert Systems with Applications, 144, 113074.
[3]. Digani, V., Hsieh, M. A., Sabattini, L., & Secchi, C. (2019). Coordination of multiple AGVs: a quadratic optimization method. Autonomous Robots, 43(3), 539-555.
[4]. Ferrara, A., Gebennini, E., & Grassi, A. (2014). Fleet sizing of laser guided vehicles and pallet shuttles in automated warehouses. International Journal of Production Economics, 157, 7-14.
[5]. Cardarelli, E., Digani, V., Sabattini, L., Secchi, C., & Fantuzzi, C. (2017). Cooperative cloud robotics architecture for the coordination of multi-AGV systems in industrial warehouses. Mechatronics, 45, 1-13.
[6]. Digani, V., Sabattini, L., Secchi, C., & Fantuzzi, C. (2015). Ensemble coordination approach in multi-AGV systems applied to industrial warehouses. IEEE Transactions on Automation Science and Engineering, 12(3), 922-934.
[7]. Chen, J., Zhang, X., Peng, X., Xu, D., & Peng, J. (2022). Efficient routing for multi-AGV based on optimized Ant-agent. Computers & Industrial Engineering, 167, 108042.
[8]. Niu, Y., Schulte, F., & Negenborn, R. R. (2021). Human Aspects in Collaborative Order Picking–Letting Robotic Agents Learn About Human Discomfort. Procedia Computer Science, 180, 877-886.

## Type of scholarship:

DM 352/2022 – Industrial Project

Study and research period outside the Hosting Institution:

1. Study and research period at the company:
   - period length: 12 months;
   - Company:
     - ICAM srl
     - S.P. 237 delle Grotte, Putignano BA 70017 Italy
     - https://www.icamonline.eu/en/
2. Study and research period abroad:
   - period length: 6 months;
   - Hosting institution:
     - Delft University of Technology - Department of Maritime and Transport
     - Leeghwaterstraat 17 2628 CA Delft – The Netherlands
     - http://www.negenborn.net/ -- http://www.mtt.tudelft.nl/

GRANT N. 27

DAUSY

D.M. 352/2022
Co-finanziata da: BluHub S.r.l.

Tematica: “Control, coordination and monitoring of autonomous agents, with application to the agrifood field”

**Research theme title:**

Control, coordination and monitoring of autonomous agents, with application to the agrifood field

**Contacts:**

Prof. Maria Domenica Di Benedetto

e-mail: mariadomenica.dibenedetto@univaq.it

**Curriculum of DAUSY:**

C3 AS for Monitoring and Security

**Hosting University/Research Centre**

University of L’Aquila

**Department:**

Department of Information and Computer Engineering and Mathematics Engineering

Università degli Studi dell’Aquila

Via Vetoio – 67100 L’Aquila (Italy)

https://www.disim.univaq.it/index

**Prospective Supervisors:**

Prof. Elena De Santis (https://www.disim.univaq.it/ElenaDeSantis)

Dr. Mario Di Ferdinando (https://www.disim.univaq.it/MarioDiFerdinando)

**Description:**

The use of autonomous vehicles in agriculture is not new: in fact, the availability of sufficiently mature ICT methodologies and technologies and, above all, the ability to act in a confined and controlled environment, have made the industrial production of fully autonomous self-driving tractors sustainable. The advantages of such automation in agriculture in terms of production cycle efficiency are unquestionable. However, the problem becomes more complicated when one thinks of actions more complex than those required for tilling a flat, unobstructed field. Indeed, the morphology and the particular task to be performed may require the coordination of different agents cooperating to achieve a common goal. Unmanned Aerial Vehicles (UAVs) systems will be considered, with the joint use of Unmanned Ground Vehicles (UGVs) and their related technologies for data collection and subsequent field action. In general, the term "drones" identifies both UAVs and UGVs. The proposed research activity aims to:

1. develop control systems, also integrating artificial intelligence methods, for the coordination of drones engaged in the realization of complex collective actions, in general not achievable by a single drone;
2. analyze and guarantee system's safety with respect to possible interactions with the environment, with particular reference to the relationship with human operators, including collaborative efforts;
3. study the interaction between automation systems for agricultural operations and data analysis algorithms for precision farming in order to achieve systems for control and optimization of crops and their maintenance.

Achieving the above goals requires the innovative development of methodologies in the control domain, in different modeling contexts, such as nonlinear systems, finite-state automata, and hybrid systems. In some cases, it will also be important to be able to represent the behavior of the system based on the availability of data gained from experience. A period of activity in the partner company is planned to acquire knowledge specific to the agrifood application area.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering, with a good background in relevant areas of interest, i.e. modelling, control and optimization. Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and interest in the application area. The project also requires soft skills to integrate research challenges and application needs.

## References:

[1]. H.T. Søgaard, I. Lund, Application Accuracy of a Machine Vision-controlled Robotic Micro-dosing System, Biosystems Engineering, Volume 96, Issue 3, 2007, Pages 315-322.
[2]. D. Anthony, S. Elbaum, A. Lorenz, C. Detweiler: On crop height estimation with UAVs. In: IEEE International Conference on Intelligent Robots and Systems, pp. 4805–4812 (2014).
[3]. K. C. Swain, S. J. Thomson, H. P. W. Jayasuriya, Adoption of an Unmanned Helicopter for Low-Altitude Remote Sensing to Estimate Yield and Total Biomass of a Rice Crop, Transactions of the ASABE (American Society of Agricultural and Biological Engineers), Volume 53, Issue 1, 2010, DOI: 10.13031/2013.29493
[4]. M. Di Ferdinando, D. Bianchi, S. Di Gennaro and P. Pepe, On the Robust Quantized Sampled-Data Leaderless Consensus Tracking of Nonlinear Multi-Agent Systems, IEEE 60th Conf. on Decision and Control, 2021.
[5]. F. Cesarone, and P. Pepe, Sample-and-Hold Solution of a Consensus Problem with Nonlinear Dynamics and Input/Output Disturbances, European Journal of Control, Vol. 59, pp. 227-237, 2021.
[6]. X. Dong, B. Yu, Z. Shi and Y. Zhong, Time-varying formation control for unmanned aerial vehicles: Theories and applications, IEEE Trans. Contr. Syst. Techn., vol. 23, pp. 340–348, 2015.
[7]. J. Hu, P. Bhowmick and A. Lanzon, Two-layer distributed formation containment control strategy for linear swarm systems: Algorithm and experiments, Int. J. Robust Nonlinear Control, vol. 30, pp. 6433– 6453, 2020.
[8]. P. Pereira, R. Cunha, D. Cabecinhas, C. Silvestre and P. Oliveira, A 3-D trailer approach to leader-following formation control, IEEE Trans. Control Syst. Technol., vol. 28, pp. 2292–2308, 2020.
[9]. S. Zhao, D. Dimarogonas, Z. Sun and D. Bauso, A general approach to coordination control of mobile agents with motion constraints, IEEE Trans. Automat. Contr., vol. 63, pp. 1509–1516, 2018.
[10]. X. Li and Y. Tang and H. R. Karimi, Consensus of multi-agent systems via fully distributed event-triggered control, Automatica, vol. 116, pp. 108898, 2020.
[11]. R. Carli, G. Cavone, N. Epicoco, M. Di Ferdinando, P. Scarabaggio and M. Dotoli, Consensus-Based Algorithms for Controlling Swarms of Unmanned Aerial Vehicles, Ad-Hoc, Mobile, and Wireless Networks. ADHOC-NOW 2020. Lecture Notes in Computer Science, vol. 12338, 2020, https://doi.org/10.1007.

## Type of scholarship:

DM 352/2022 – Industrial Project

**Study and research period outside the Hosting Institution:**

1. Study and research period at the company:
   - period length: 8 months;
   - Company:
     - BluHub
     - Piazza S. Allende n. 4, 65100 Pescara
     - https://www.bluhub.it/
2. Study and research period abroad:
   - period length: 6 months;
   - Hosting institution:
     - University Polytechnic Hauts-de-France - https://www.uphf.fr/
     - LAMIH CNRS-UMR 8201, Campus du Mont Houy, F-59313 VALENCIENNES CEDEX 9
     - https://www.uphf.fr/LAMIH/en/frontpage/

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 28

# DAUSY

## D.M. 352/2022
## Co-finanziata da: STAM S.r.l.
## Tematica: "Development of solutions for mobile and collaborative robotics in complex environments"

**Research theme title:**

Development of solutions for mobile and collaborative robotics in complex environments

**Contacts:**

Prof. Lorenzo Marconi

email: lorenzo.marconi@unibo.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Alma Mater Studiorum - Università di Bologna, Italy

**Department:**

Dipartimento di Ingegneria dell'Energia Elettrica e dell'Informazione "Guglielmo Marconi"

**Prospective Supervisors:**

Prof. Lorenzo Marconi, Università di Bologna (lorenzo.marconi@unibo.it)

Stefano Ellero, STAM S.r.l. (s.ellero@stamtech.com)

**Description:**

In the recent years, there has been a rapid increase of mobile robots' implementation in industrial settings, with a particular focus on automatic warehouse management. While advancements in mobile robots are contributing to the realization of a smarter and more efficient movement of goods inside warehouses, these results can only be achieved with good performances and repeatability in structured and simpler environment. As a consequence, the use of mobile robots in more complex environment (e.g.: agriculture, construction sites, rescue activities) is becoming of high interest for the expansion of robotics outside manufacturing.

The goal of this project is to develop software solutions for the collaborative use of mobile robots in complex and unstructured environments, such as agriculture (arable crops, orchards, etc.), construction sites, and harsh manufacturing scenarios. Robot navigation functionalities will be achieved through the development of a robust guidance systems for autonomous robot navigation in unstructured and dynamic environment, developing and implementing path-planning, collision avoidance, driving, navigation, and control algorithms. On the other side, the collaboration with humans will be achieved through the development of environment

cognition techniques, based on machine vision, and immersive human-machine interaction through extended reality and natural human-robot communication.

The research will be applied to real scenarios provided by Stam S.r.l., an Italian SME specialized in innovative and collaborative robotic solutions for manufacturing and construction industries.

Specific Information:

Applicants must hold a master's degree, preferably in Engineering (mechanical, robotics, mechatronic, IT), with a good background in relevant areas of interest (i.e., computer vision, machine learning, and control). Solid coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian engineering company, which will be the integrator of the technologies.

References:

[1]. R. Tazzari, D. Mengoli and L. Marconi, "Design Concept and Modelling of a Tracked UGV for Orchard Precision Agriculture", 2020 IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor), 2020, pp. 207-212, doi: 10.1109/MetroAgriFor50201.2020.9277577.
[2]. Gentilini, Lorenzo, Dario Mengoli, and Lorenzo Marconi. "Direct Bézier-Based Trajectory Planner for Improved Local Exploration of Unknown Environments". arXiv preprint arXiv:2203.00968 (2022).
[3]. D. Mengoli, R. Tazzari and L. Marconi, "Autonomous Robotic Platform for Precision Orchard Management: Architecture and Software Perspective", 2020 IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor), 2020, pp. 303-308, doi: 10.1109/MetroAgriFor50201.2020.9277555.
[4]. D. Mengoli, A. Eusebi, S. Rossi, R. Tazzari and L. Marconi, "Robust autonomous row-change maneuvers for agricultural robotic platform", 2021 IEEE International Workshop on Metrology for Agriculture and Forestry (MetroAgriFor), 2021, pp. 390-395, doi: 10.1109/MetroAgriFor52389.2021.9628694.
[5]. R. Tazzari, I. A. Azzollini and L. Marconi, "An Adaptive Observer approach to Slip Estimation for Agricultural Tracked Vehicles", 2021 European Control Conference (ECC), 2021, pp. 1591-1596, doi: 10.23919/ECC54610.2021.9654998.
[6]. Azzollini, Ilario Antonio, et al. "UAV-Based Search and Rescue in Avalanches using ARVA: An Extremum Seeking Approach". arXiv preprint arXiv:2106.14514 (2021).

Type of scholarship:

DM 352/2022 – Industrial Project

Study and research period outside the Hosting Institution:

1. Study and research period at the company:
   - period length: 18 months;
   - Company:
     - STAM S.r.l., Via Pareto 8Ar, 16129 Genova, Italy (https://www.stamtech.com/)
2. Study and research period abroad:
   - period length: 6 months;
   - Hosting institution:
     - Wageningen Centre for Development Innovation, Droevendaalsesteeg 1 - Building 107 (Radix) - 6708 PB Wageningen - The Netherlands (https://www.wur.nl/)

## GRANT N. 29

## DAUSY

D.M. 352/2022
Co-finanziata da: “Thales Alenia Space Italia S.p.A”
Tematica: “Artificial Intelligence and Control Tools for Cognitive Satellite SAR Systems”

**Research theme title:**

Artificial Intelligence and Control Tools for Cognitive Satellite SAR Systems

**Contacts:**

Giuseppe Notarstefano, Università di Bologna

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Università di Bologna

**Department:**

Department of Electrical, Electronic and Information Engineering G. Marconi

https://dei.unibo.it

Viale del Risorgimento, 2, Bologna, Italy

**Prospective Supervisors:**

Giuseppe Notarstefano, Università di Bologna

Andrea Pietropaolo, Thales Alenia Space Italia S.p.A.

Carlo Ciancarelli, Thales Alenia Space Italia S.p.A.

**Description:**

The availability of powerful devices for digital processing is bringing new opportunities for Radio Frequency (RF) payloads and microwave instruments as well as new challenges, due to higher sampled bandwidth and data rates to be processed. Artificial Intelligence (AI) and control methods include a set of techniques and theories worth exploring in the context of on-board data processing for such payloads, with many possible applications: data reduction (reducing the amount of data to be sent to the ground segment); algorithm acceleration (increasing the payload efficiency); increased operational autonomy (enabling smarter payloads with capabilities to autonomously change operational modes, among others).

Evaluating AI and control methods for a set of reference scenarios will pave the way for their deployment in future RF payloads and microwave instruments. This goal will be pursued through requirement analysis; model selection; optimization; validation and benchmarking in hardware with AI accelerators. Scenarios will need to be defined in the research project in the frame of current applications such as signal identification and very wideband spectrum monitoring for Radio Frequency Interference (RFI), focusing on cognitive SAR applications applicable to the Earth Observation domain, with on-board feature identification and autonomous resource allocation.

**Specific Information:**

Applicants must hold a scientific master's degree, preferably in (Control, Electrical, Information) Engineering, with a strong background in relevant areas of interest as optimization, control, machine learning. Solid coding skills, including mathematical simulation software, are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities in the area of optimization, control, signal processing and learning, involving both theoretical analysis and experimental validation, in strong connection with a leading aerospace company, which will be the end-user of the developed technologies.

**References:**

Haykin S. Cognitive radar: a way of the future. IEEE signal processing magazine. 2006 Feb 13; 23(1) : 30-40.

Geng Z, Yan H, Zhang J, Zhu D. Deep-learning for radar: A survey. IEEE Access. 2021 Oct 13 ; 9:14 1800-18.

Abad R., Ierkic M., Ortiz-Rivera E. (2016) Basic understanding of cognitive radar. 1-4. 10.1109/ ANDESCON. 2016.7836270.

Stinco P., Giusti F., Bacci A., Martorella M., Berizzi F., Gini F., Greco M. S., Saverino A. L. (2014) Cognitive Synthetic Aperture Radar.

Greco M. S., Gini F., Stinco P., Bell K., Cognitive Radars: A Reality? arXiv preprint:1803.01000 2018

Camisa A, Notarnicola I, Notarstefano G. Distributed primal decomposition for large-scale MILPs. IEEE Transactions on Automatic Control. 2021 Feb 4;67(1):413-20.

Camisa A, Notarstefano G. A Distributed Mixed-Integer Framework to Stochastic Optimal Microgrid Control. IEEE Transactions on Control Systems Technology. 2022 May 24.

Sforni L, Spedicato S, Notarnicola I, Notarstefano G. GoPRONTO: a Feedback-based Framework for Nonlinear Optimal Control. arXiv preprint arXiv:2108.13308. 2021 Aug 30.

Sforni L, Notarnicola I, Notarstefano G. Learning-driven nonlinear optimal control via gaussian process regression. In 2021 60th IEEE Conference on Decision and Control (CDC) 2021 Dec 14 (pp. 4412-4417).

**Type of scholarship:**

DM 352/2022 – Industrial Project

**Study and research period outside the Hosting Institution:**

1. Study and research period at the company:
   - period length: 6-12 months;
   - Company:
     - Thales Alenia Space Italia S.p.A.
     - Via Saccomuro, 24, 00131, Rome, Italy
     - https://www.thalesgroup.com/en/italy

2. Study and research period abroad:
   - period length: 6 months;
   - Position: visiting scientist
   - Hosting institution:
     - European Space Agency (ESA)
     - ESTEC Keplerlaan 1
     - NL-2201 AZ Noordwijk, The Netherlands
     - www.esa.int

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 30

# DAUSY

## D.M. 352/2022
## Co-finanziata da: CIRCLE S.p.a
## Tematica: "Monitoring and optimally managing goods movements on multimodal networks"

**Research theme title:**

Monitoring and optimally managing goods movements on multimodal networks

**Contacts:**

Prof. Simona Sacone

e-mail: simona.sacone@unige.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Genova, Italy

**Department:**

Department of Informatics, Bioengineering, Robotics and Systems Engineering

Via Opera Pia 13, 16145 Genova, Italy

www.dibris.unige.it

**Prospective Supervisors:**

Prof. Simona Sacone (simona.sacone@unige.it)

Prof. Roberto Sacile (roberto.sacile@unige.it)

**Description:**

The activity refers to the design of monitoring and optimal management of freight transport operations in networks with multiple transport modes available. In this context, not only offline planning, but also online monitoring and control activities are crucial for an effective and sustainable realization of the requested movements. The activity will specifically consider the following aspects:

- methods and tools for traffic evaluation and forecasting
- minimization of waiting times and management costs
- definition of innovative and effective management schemes as transport federative platforms (cooperative logistics), evolutive truck appointment systems and customs evolutive port tracking interoperability

## Specific Information:

Applicants must hold a Master's degree, preferably in Engineering, with a good background in relevant areas of interest (i.e., modelling, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. C. Caballini, S. Sacone, M. Saaednia, "Cooperation among carriers in seaport containerized transportation", Transportation Research E, 93, pp. 38–56, 2016
[2]. M. Zhang, M. Janic, L.A. Tavasszy, "A freight transport optimization model for integrated network, service, and policy design", Transportation Research E, 77, pp. 61-76, 2015
[3]. C. Caballini, M. D. Gracia, J. Mar-Ortiz, S. Sacone, "A combined Data Mining - Optimization Ap- proach to Manage Trucks Operations in Container Terminals with the use of a TAS. Application to an Italian and a Mexican port", Transportation Research E, 142, 2020
[4]. C. Archetti, L. Peirano, M.G. Speranza "Optimization in multimodal freight transportation problems: A Survey" European Journal of Operational Research, 299, 2022

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

1. Study and research period at the company:
   - period length: 12 months;
   - Company:
     - Circle SpA
     - Piazza Borgo Pila 40/46, 16129 Genova Italy
     - https://www.circlegroup.eu/
2. Study and research period abroad:
   - period length: 6 months;
   - Hosting institution:
     - Delft University of Technology
     - Leeghwaterstraat 17 2628 CA Delft – The Netherlands

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 31

# DAUSY

## D.M. 352/2022
## Co-finanziata da: IVECO DV&ASTRA
## Tematica: “Motion planning, control and coordination of off-road autonomous mining trucks”

**Research theme title:**

Motion planning, control and coordination of off-road autonomous mining trucks

**Contacts:**

Prof. Paolo Falcone

e-mail: falcone@unimore.it

Dr. Marianna Vivolo

e-mail: marianna.vivolo@ivecogroup.com

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Modena and Reggio Emilia

**Department:**

Department of Engineering ‘Enzo Ferrari’

https://www.ingmo.unimore.it/site/en/home.html

**Prospective Supervisors:**

Prof. Paolo Falcone (falcone@unimore.it)

Dr. Marianna Vivolo (marianna.vivolo@ivecogroup.com)

**Description:**

The main objective of this project is the development and the experimental validation of motion planning and control algorithms of off-road autonomous mining trucks.

An off-road autonomous vehicle is expected to be capable of executing challenging driving tasks like, e.g., navigating through rough, uneven terrains, climbing high-slope paths, while operating in a wide range of load conditions. In this project we will assume that a sensing and perception stack is available, which provides the mining truck with the necessary information about the environment, including a description of the road surface ahead. Such a description must include road surface information such that the motion planning algorithm can plan a path that is compatible with the traversability capabilities of the vehicle. For this reason,

the motion planning also needs a description of the current vehicle's capability from the control layer. Design such a planning and control architecture is challenging. In particular, how to distill a description (in terms of state and input constraints?) of the vehicle's capabilities w.r.t. the road surface is to be understood. We will explore predictive control approaches in this project, which are proven to be very much effective in embedding vehicle's state and input constrains that could well describe the vehicle capability and the road surface shape.

The developed algorithms will be tested in a simulation environment first. Then, they will be experimental validated through an 8x8 off-road mining truck prototype manufactured by Iveco.

## Specific Information:

Applicants must hold a master's degree in Engineering or in neighboring fields (Math, Engineering Physics) with a good background in relevant areas of interest (i.e. learning, optimization, and control). Solid mathematical and coding skills are welcome. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation.

## References:

[1]. Batkovic, I., Ali, M., Falcone, P., & Zanon, M. Safe trajectory tracking in uncertain environments. arXiv preprint arXiv:2001.11602, 2020.
[2]. Batkovic, I., Rosolia, U., Zanon, M., & Falcone, P. A robust scenario MPC approach for uncertain multi-modal obstacles. IEEE Control Systems Letters, 5(3), 2020.
[3]. A. Toytziaridis, P. Falcone, and J. Sjöberg, "A data-driven markovian framework for multi-agent pedestrian collision risk prediction," IEEE Intell. Transp. Syst. Conf., 2019.
[4]. Falcone, P., Borrelli, F., Asgari, J., Tseng, H. E., & Hrovat, D. (2007). Predictive active steering control for autonomous vehicle systems. *IEEE Transactions on control systems technology*, *15*(3), 566-580.
[5]. Falcone, P., Borrelli, F., Tseng, H. E., Asgari, J., & Hrovat, D. (2008). Linear time-varying model predictive control and its application to active steering systems: Stability analysis and experimental validation. *International Journal of Robust and Nonlinear Control: IFAC-Affiliated Journal*, *18*(8), 862-875.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

- 12 months at Iveco Defense Vehicles, Via Alessandro Volta, 6/1, 39100 Bolzano BZ, https://www.ivecodefencevehicles.com;
- 6 months at Department of Electrical Engineering, Chalmers University of Technology, Gothenburg, Sweden.

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 32

# DAUSY

## D.M. 352/2022
## Co-finanziata da: GSK Manufacturing S.p.a.
## Tematica: "Predictive maintenance, fault and anomaly detection for chemical and pharmaceutical processes"

**Research theme title:**

Predictive maintenance, fault and anomaly detection for chemical and pharmaceutical processes

**Contacts:**

Luca Consolini

e-mail: luca.consolini@unipr.it

**Curriculum of DAUSY:**

C2 AS for Smart Environments

**Hosting University/Research Centre**

University of Parma, Italy.

**Department:**

Dipartimento di Ingegneria e Architettura,

Parco Area delle Scienze 181/A, Parma.

**Prospective Supervisors:**

Luca Consolini (www.ce.unipr.it/people/lucac/)

Aurelio Piazzi (www.ce.unipr.it/people/piazzi/)

Gianluigi Ferrari (http://www.tlc.unipr.it/ferrari/)

**Description:**

Pharmaceutical production involves complex and critical processes. Various sensors monitor process variables (for instance, temperatures and pressures) to ensure that all phases respect specifications, and that the drug product is of the desired quality. Pharmaceutical plants store process data for years of operation. Potentially, these data can be used to evaluate the state of the plant, and to detect possible faults. Sudden variations of process signals allow to detect anomalies, while slow variations of measured signals can be used to perform predictive maintenances.

In particular, this research will be focused on freeze-drying. This is a standard process in pharmaceutical industry, used to stabilize, store and increase the shelf life of drug products. The product has to be brought to

a very low pressure and the lyophilization chamber has to be perfectly sealed. Even small external leaks can contaminate the entire drug batch. Since a single batch may contain thousands of product vials, freeze-dryer leakages are one of the most critical problems of the entire production chain of lyophilized drugs.

First, the research will evaluate mathematical models for lyophilizers, able to describe possible faults. Then, the research will formulate algorithms for identifying process anomalies and, in particular, for finding and separating internal and external leaks.

The research will be carried out in collaboration with pharmaceutical company GSK, which is the final user of the developed methods. The proposed algorithms will be implemented and tested in GSK production plant in San Polo di Torrile (PR).

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering or Mathematics, with a good background in relevant areas of interest (mathematics, optimization, and control). The candidate should have very good mathematical and good coding skills. The applicant should be proficient in written and spoken English. The candidate should be interested in the theme of data analysis for process industry.

## References:

[1]. G. Calzavara, L. Consolini and G. Ferrari (2021) *Leak Detection and Classification in Pharmaceutical Freeze-Dryers: an Identification-Based Approach*, 60th IEEE Conference on Decision and Control (CDC), pp. 1568-1573.
[2]. Huang, H., Mohan, C. K., Mehrotra, K. G. (2017). *Anomaly Detection Principles and Algorithms*. Springer International Publishing.
[3]. J. D. Mellor et al. (2004) *Fundamentals of freeze-drying*, John Wiley & Sons.
[4]. Roth (2012), *Vacuum technology*, Elsevier.
[5]. H. Rottlander, W. Umrath, and G. Voss (2016) *Fundamentals of leak detection*, Leybold GMBH (ed) Cat, vol. 199, p. 37.
[6]. J. John and T. Keith (2006) *Gas Dynamics,* Pearson Prentice Hall.
[7]. A. Istratov and O. F. Vyvenko (1999) *Exponential analysis in physical phenomena*, Review of Scientific Instruments, vol. 70, no. 2, pp. 1233–1257.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

- The research will require at least 6 months of research in the GSK production plan in San Polo di Torrile, near Parma (https://it.gsk.com/it-it/chi-siamo/produzione/il-sito-produttivo-di-san-polo-di-torrile/).
- The research will require at least 6 months of research in a GSK R&D center in Rockville, United States (https://www.gsk.com/en-gb/research-and-development/rd-locations/), 4200 Shady Grove Rd Rockville, MD 20850, USA

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 33

# DAUSY

## D.M. 352/2022
## Co-finanziata da: MAFINA S.r.l.
## Tematica: "Causal representation learning for time series monitoring in continuous food manufacturing processes"

**Research theme title:**

Causal representation learning for time series monitoring in continuous food manufacturing processes

**Contacts:**

Prof. Paolo Fiorini

e-mail: paolo.fiorini@univr.it

**Curriculum of DAUSY:**

C3 AS for Monitoring and Security

**Hosting University/Research Centre**

University of Verona, Italy

**Department:**

Department of Computer Science

Strada le Grazie, 15, 37134 Verona - Italy

https://www.di.univr.it

**Prospective Supervisors:**

Prof. Paolo Fiorini (https://www.di.univr.it/?ent=persona&id=9&lang=it)

Dr. Diego Dall'Alba (https://www.di.univr.it/?ent=persona&id=6321&lang=it)

**Description:**

The Industry 4.0 paradigm is allowing the acquisition of large volumes of data, thanks to the availability of sensors and the easy interconnectivity among machines. However, the correct and useful processing of the data collected is still far from being solved. This problem is affecting industries in all sectors, but it is more significant in continuous production, especially for processed food. Here, product quality is affected not only by the plant variables, but also by external variables, such as humidity, heat, and raw material quality.

In this sector, quality is often demanded to production line workers who know how to adjust the plant parameter based on their experience. Unfortunately, the diversification of products, the variety of supplier quality and the retirement of production experts, makes it necessary to find alternate and more repeatable solutions.

A successful PhD thesis has addressed the problem of process modeling by introducing causality in the data collected to identify more precisely the relations existing among the variables and the steps of product processing. However, the results are still not sufficient to develop an accurate plant monitoring system and an advisory system that could indicate the parameter adjustments to the plant operators.

The goal of this project is to develop a robust plant monitoring system that could predict with a reasonable level of accuracy the product quality and could suggest the appropriate parameter changes to the plant operators. We will expand the causality approach developed so far and will integrate it with other identification and modeling tools, e.g. supervised, unsupervised, and reinforcement learning, to better model the employees experience and to map it to corrective actions for the plant. Attention will be also given to the implementation parts of the project, to design and set up the appropriate infrastructure capable of handling the data flow, at different time rates and resolution.

## Specific Information:

Applicants must hold a master's degree, preferably in Computer Science or Engineering, with a good background in areas related to data driven modelling and control. Solid mathematical and coding skills are necessary. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian processed food manufacturer, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. G. Menegozzo, D. Dall'Alba, P Fiorini, ""Causal interaction modeling on ultra-processed food manufacturing," in 2020 IEEE 16th International Conference on Automation Science and Engineering (CASE), 2020, pp. 200–205.
[2]. G. Menegozzo, D. Dall'Alba, and P. Fiorini, "Industrial time series modeling with causal precursors and separable temporal convolutions," IEEE Robotics and Automation Letters, vol. 6, no. 4, pp. 6939–6946, 2021.
[3]. A. Scavarda, T. Bouzdine-Chameeva, S. Goldstein, J. Hays, and A. Hill, "A methodology for constructing collective causal maps," Decision Sciences, vol. 37, no. 2, pp. 263–283, 2006.
[4]. B. Scholkopf, F. Locatello, S. Bauer, N. R. Ke, N. Kalchbrenner, A. Goyal, and Y. Bengio, "Toward causal representation learning," Proceedings of the IEEE, vol. 109, no. 5, pp. 612–634, 2021.
[5]. J. Peters, D. Janzing, and B. SchÅNolkopf, Elements of Causal Inference: Foundations and Learning Algorithms. Cambridge, MA, USA: MIT Press, 2017.
[6]. J. Pearl, "The seven tools of causal inference, with reflections on machine learning" Communications of the ACM, vol. 62, pp. 54–60, 2019.
[7]. M. Vuković, S. Thalmann, Causal Discovery in Manufacturing: A Structured Literature Review. Journal of Manufacturing and Materials Processing. 2022.
[8]. A.R. Nogueira, J. Gama, C.A. Ferreira, Causal discovery in machine learning: Theories and applications. Journal of Dynamics & Games. 2021.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

1. Study and research period at the company:
   - period length: 12 months;

- Company:
  - Mafin srl
  - Strada degli alberi 7, 35015 Galliera Veneta, Padova – Italy
  - https://mafin.it/

2. Study and research period abroad:

- period length: 6 months;
- Hosting institution:
  - Technische Universität Darmstadt – Computer Science Department
  - Hochschulstr. 10 D-64289 Darmstadt
  - https://www.ias.informatik.tu-darmstadt.de/

Finanziato dall'Unione europea
NextGenerationEU

# GRANT N. 34

# DAUSY

## D.M. 352/2022
## Co-finanziata da: CNH INDUSTRIAL ITALIA S.p.a.
## Tematica: "Predictive Maintenance and Anomaly Detection for Agricultural Tractors Components"

**Research theme title:**

Predictive Maintenance and Anomaly Detection for Agricultural Tractors Components

**Contacts:**

Prof. Sauro longhi

e-mail: sauro.longhi@univpm.it

**Curriculum of DAUSY:**

C3 AS for Monitoring and Security

**Hosting University/Research Centre**

Università Politecnica delle Marche

**Department:**

Department of Information Engineering

via Brecce Bianche 12, 60131 Ancona - Italy

https://www.dii.univpm.it/node/391?language=en

**Prospective Supervisors:**

Prof. Sauro Longhi (sauro.longhi@univpm.it)

**Description:**

The new technologies that the industrial revolution 4.0 has provided to autonomous systems have allowed to improve and automate different aspects of the systems, particularly thanks to the big amount of data now available to analyze and predict the system behaviour. This knowledge can improve the system monitoring and control and give an important contribution to develop better decision-making strategies and to optimize maintenance and costs for the autonomous systems.

The research activity aims to develop methodologies for the analysis of data from multiple sources (sensors onboard, data lake, etc.) in order to plan actions to be taken to improve the reliability and optimize the performance of the system components, while ensuring the safety of the people involved and the correct functioning of the components themselves.

Thus, the main challenges will lie in defining efficient techniques (data-driven and / or model-based) for predictive maintenance and anomaly detection for mechanical components aimed at predicting and preventing faults and anomalies.

The research will be applied to real scenarios provided by CNH Industrial Italia SpA.

## Specific Information:

Applicants must hold a master's degree, preferably Engineering, with a good background in relevant areas of interest (i.e., probability and statistics, system identification, systems and control theory and machine learning). Proficiency in both spoken and written English is required. Coding and teamwork skills are encouraged.

## References:

[1]. M. Kordestani, M. Saif, M. E. Orchard, R. Razavi-Far and K. Khorasani, "Failure Prognosis and Applications—A Survey of Recent Literature," in *IEEE Transactions on Reliability*, vol. 70, no. 2, pp. 728-748, June 2021, doi: 10.1109/TR.2019.2930195.
[2]. S. Vollert and A. Theissler, "Challenges of machine learning-based RUL prognosis: A review on NASA's C-MAPSS data set," *2021 26th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA)*, 2021, pp. 1-8, doi:10.1109/ETFA45728.2021.9613682.
[3]. Samy, I., Postlethwaite, I., & Gu, D. W. (2011). Survey and application of sensor fault detection and isolation schemes. *Control Engineering Practice*, *19*(7), 658-674.
[4]. Hwang, S. Kim, Y. Kim and C. E. Seah, "A Survey of Fault Detection, Isolation, and Reconfiguration Methods," in *IEEE Transactions on Control Systems Technology*, vol. 18, no. 3, pp. 636-653, May 2010, doi: 10.1109/TCST.2009.2026285.
[5]. Wang, W. Q., Golnaraghi, M. F., & Ismail, F. (2004). Prognosis of machine health condition using neuro-fuzzy systems. *Mechanical Systems and Signal Processing*, *18*(4), 813-831.
[6]. Isermann, R. (1984). Process fault detection based on modeling and estimation methods—A survey. *Automatica*, *20*(4), 387-404.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

- 6 to 18 months of the study shall be performed at:

Hosting company

- CNH INDUSTRIAL ITALIA SPA

Viale Delle Nazioni 55 - 41122 Modena (MO), Italy
https://www.cnhindustrial.com/it-IT

- 6 to 18 months of the study shall be performed as a research period abroad at:

Hosting institution

- Universite de Lorraine

CRAN UMR 7039, CNRS - Faculté des Sciences et Technologies - B.P. 7023954506 VANDOEUVRE-LES-NANCY, FRANCE
www.cran.univ-lorraine.fr/

Finanziato dall'Unione europea
NextGenerationEU

GRANT N. 35

DAUSY

D.M. 352/2022
Co-finanziata da: SCHNELL S.p.a.
Tematica: "Self-diagnosis and total fault prediction solutions based on data and signals in autonomous machines for structural steel processing"

**Research theme title:**

Self-diagnosis and total fault prediction solutions based on data and signals in autonomous machines for structural steel processing

**Contacts:**

Prof. Longhi Sauro

e-mail: sauro.longhi@univpm.it

**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Università Politecnica delle Marche, Italy

(Marche Polytechnic University, Italy)

**Department:**

Dipartimento di Ingegneria dell'Informazione - DII

(Department of Information Engineering – DII)

Via Brecce Bianche, 12, 60131, Ancona, Italy

https://www.dii.univpm.it/

**Prospective Supervisors:**

Prof. Longhi Sauro (sauro.longhi@univpm.it)

**Description:**

In the context of Industry 4.0 the need for even more intelligent production systems organised as cyber-physical production systems (CPPSs) is increasing the focus on Predictive Maintenance (PdM) strategies to increase the utilization rate (availability) of production equipment and decrease the cost of downtime. By affecting equipment availability, PdM have a direct impact on the overall effectiveness of both equipment and throughput, generating both cost and time savings. The aims are to establish an intelligent, interoperable, and autonomous production environment. The problem of self-diagnosis and total fault prediction solutions is receiving enormous interest for an efficient and reconfigurable manufacturing environment. Collaborative robots or automatic devices for handling the tools change or to feed the automatic machineries without

human intervention in an automated shopfloor of smart factories is indeed a significant challenge for the real-time control and management aimed at predicting and preventing downtime while ensuring an increase in machines availability, productivity, and production flexibility. The objective of this project is to estimate the wear of the automatic machineries, mainly in their critical components such as tools, motor operated devices, actuators, mechanical or electrical devices, etc. in order to go towards self-diagnosis and total fault prediction of these machines. Further investigations and results should relate to solutions to predict production and machines needs without human intervention. For the purposes of predictive maintenance, algorithms and solutions must be studied in a broad spectrum considering multiple approaches, such as signal-based, data-driven, machine learning and so on, the solutions must be focused on forecasting the residual useful life of the devices. analyzed and of the machinery in a more general sense.

## Specific Information:

Applicants must hold a master's degree, preferably in Engineering. A good background in relevant areas of interest (i.e., machine learning, optimization, and control) is desirable. Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian company market leader in the production of automatic machinery for construction sector, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

## References:

[1]. Bonci, A. Di Biase, A. F. Dragoni, S. Longhi, P. Sernani, A. Zega, "Machine learning for monitoring and predictive maintenance of cutting tool wear for clean-cut machining machines" 27th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA22), Stuttgart, Germany, Sept 6-9, 2022 (under publication).
[2]. Bonci S. Longhi, G. Nabissi, F. Verdini, "Predictive Maintenance System using motor current signal analysis for Industrial Robot" 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA19), Zaragoza, Spain, Sept 10-13, 2019, pp. 1453-1456
[3]. Bonci, S. Longhi, G. Nabissi, "Fault Diagnosis in a belt-drive system under non-stationary conditions. An industrial case study" Proceedings - 2021 IEEE Workshop on Electrical Machines Design, Control and Diagnosis, WEMDCD 2021, pp. 260-265.
[4]. Bonci, Pangcheng David Cen Cheng, M. Indri, G. Nabissi and F. Sibona. "Human-Robot Perception in Industrial Environments: A Survey", Sensors MDPI, Vol. 21, Issue 5, pp. 1-29, Feb. 24, 2021.
[5]. Bonci, D. Stadnicka, S. Longhi, "The Overall Labour Effectiveness to Improve Competitiveness and Productivity in Human-Centered Manufacturing", Lecture Notes in Mechanical Engineering, pp. 144-155, 2022.
[6]. Bonci, S. Longhi, G. Nabissi and G. A. Scala. "Execution Time of Optimal Controls in Hard Real Time, a Minimal Execution Time Solution for Nonlinear SDRE", IEEE Access, Vol. 8, Issue 1, pp. 158008-158025, Aug. 27, 2020.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

1. Study and research period at the company:

- period length: 6-12 months;
- Company:
  - SCHNELL SpA, Via Sandro Rupoli, 2 – Colli al Metauro (PU) Italy https://www.schnellgroup.com/en/

2. Study and research period abroad:
   - period length: 6 months;
   - Hosting institution:
     - Maynooth University - Department of Electronic Engineering, Maynooth, Co. Kildare, Ireland
     - https://www.maynoothuniversity.ie/electronic-engineering
     - https://coer.maynoothuniversity.ie
     - http://www.eeng.nuim.ie/jringwood/