Call for applications for admission to XXXVIII Cycle of Politecnico di Bari PhD Programmes

Attachment 6

PhD PROGRAMME IN INDUSTRY 4.0

Inter-university course in collaboration with University of Bari "Aldo Moro"

Project Identification Code (CUP): D93C22000560001; D93D22001370001

XXXVIII CYCLE DOCTORATE PROGRAMME PROFILE	
DEPARTMENT	Department of Electrical Engineering and Information Technology
COORDINATOR	Prof. Gennaro Boggia (gennaro.boggia@poliba.it)
PLACES AVAILABLE	14
of which	
Places with Politecnico di Bari grant	2
*Places with **Politecnico di Bari grant reserved** for graduates from non-Italian universities*	1
*Places with **Uniba** grant*	3
*Places with grant funded by NRRP – as per Ministerial Decree **351/2022*** ___Refer to research topic list below___	3 of which: GRANT N. 1 - **Area:** NRRP; **Topic: "***Platforms for the optimization and control of drone-as-a-service in logistics"***; GRANT N. 2 - **Area:** NRRP; **Topic: "***SANI - Development of sustainable anti-microbial nanomaterials for innovation in the food industry***"; GRANT N. 3 - **Area:** Public Administration; **Topic: "***Development of AI-based advanced control strategies for urban mobility***".
*Places with grant funded by NRRP – as per Ministerial Decree **352/2022*** ___Refer to research topic list below___	2 of which: GRANT N. 4 - **Co-funded by**: Manta Group s.r.l.; **Topic: "***Energy flexibility using storage systems for industrial buildings"***; GRANT N. 5 - **Co-funded by**: Hevolus s.r.l.; **Topic: "***Tools and methods to make the Metaverse accessible to Italian SMEs and others"***.
Places without grant funding	3
ADMISSION REQUIREMENTS *Applicants to the PhD programme in Industry 4.0 **must hold a second level (specialized) degree***	➢ Degree diploma awarded by the Italian university system prior to Ministerial Decree 509/99; ➢ Specialist Degree (as per Ministerial Decree 509/99); ➢ Master's Degree (as per Ministerial Decree 270/04); ➢ Degree qualifications awarded by foreign universities officially recognised as equivalent[1].

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[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 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.*

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.

REQUIRED DOCUMENTATION *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. *(File to be named "01.CV").* ➢ **Copy of a current identification document**. Only the following documents will be considered eligible: • ID cards issued by an EU member state; • driving licence issued by an EU member; • in all other cases, a full validity passport (also non-EU citizens). *(File 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)**. **Candidates with qualifications awarded in Italy** <u>must</u> attach the Politecnico form available at https://www.poliba.it/it/dottorati-di-ricerca, specifying: • final degree mark; • a list of all exams taken with their relative marks in both degree courses (or the Single Cycle course); • results of exams taken. *(File to be named "03.Titoli di Laurea").* **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).

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[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 "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 F_FORMAT PROPOSTA DI RICERCA_DRI4.0.doc*"):** **https://www.poliba.it/sites/default/files/dottorati/allegato_f_format_proposta_di_ricerca_dri_4.0_english.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. *(File to be named "06.Proposta di 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. *(File to be named "07.Dichiarazione altri titoli")*.
	➤ **Either one or two letters of reference from teaching staff** who have supervised the candidate throughout their university-level studies. *(Files to be named "08.Lettera presentazione 1", "08. Lettera presentazione 2")*.
	➤ **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.

	(File to be named "09.Certificazione linguistica 1"; etc).
	➤ **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.
	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.
	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.
	(File to be named "10.Pubblicazione 1"; etc).
DOCUMENT CHECKLIST	**Required documentation:**
	➤ **CV** *(to be named "01.CV")*;
	➤ **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")*;
	➤ **Abstract of the thesis topic for specialist/Master's degree (or five-year Single Cycle degree)** *(to be named "04.Abstract Tesi")*;
	➤ **Candidate thesis for specialist/Master's degree (or five-year Single Cycle degree)** *(to be named "05.Tesi")*;
	➤ **PhD research proposal** (*to be named "06.Proposta di Ricerca")*.
	Optional documentation:
	➤ **Self-certification declaration for any other qualifications** *(to be named "07.Dichiarazione altri titoli")*;
	➤ **Either one or two letters of reference from teaching staff** *(to be named "08.Lettera presentazione 1", "08. Lettera presentazione 2")*;

	➢ **Language certification** *(to be named "09.Certificazione linguistica 1"; etc*); ➢ **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. 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; Tuesday 13 Sept 2022; Wednesday 14 Sept 2022; Thursday 15 Sept 2022; Friday 16 Sept 2022.

The Examination Board will assess candidates' qualifications and interview with a mark **out of 100** (maximum mark for qualifications 40 and interview 60).
Candidates awarded less than **10 marks** for the **qualification evaluation** will not be admitted to the interview phase of the selection process.

The minimum pass mark for the **interview is 15**.

The minimum overall pass mark for the selection procedure is 25.

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.

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

LIST OF RESEARCH TOPICS FOLLOWS

Topic: "Platforms for the optimization and control of drone-as-a-service in logistics"

Research Proposal - ABSTRACT:

Drones, also known as unmanned air vehicles (UAVs), represent a key enabling technology of Industry 4.0, thanks to their functionality and versatility in several industrial and logistic sectors. Over the past few years, UAVs have become pivotal for several businesses and governmental organizations and have managed to pierce through areas where certain industries were either stagnant or lagging behind. From quick deliveries at rush hour to scanning an unreachable military base, drone features are proving to be extremely beneficial in places where men cannot reach or are unable to perform in a timely and efficient manner. Recently, drones also offer industrial and logistic companies several top uses – that are referred to as the paradigm of Drone-as-a-Service (DaaS) – aimed at increasing work efficiency and productivity, decreasing workload and production costs, improving accuracy, refining service and customer relations, and resolving safety issues on a vast scale.

Drones can perform both outdoor and indoor missions in very challenging environments and their applications and services cover a wide range of logistic applications. Drones' applications can be categorized in different ways. On the one hand, the categorization can be based on the type of missions (military/civil), type of the flight zones (outdoor/indoor), and type of the environments (underwater/on the water/ground/air/space). On the other hand, the categorization can be based on the drones' capabilities to "see", "sense", "move", and "transform". "See" is the capability of collecting visual data, often in the forms of images and videos. In logistics, examples are the visual inspection of equipment and the monitoring of the operators' safety and ergonomics such as during maintenance operations where fixed cameras are not economically feasible. "Sense" is the capability of collecting data and transforming them into other forms of data or structured data (i.e. information) without performing additional physical operations. Some relevant examples in logistics include thermal inspection of equipment and machines, gas detection, tracking and finding lost pallets and slots for inventory management. "Move" is the ability of a drone system to grasp and carry objects or perform physical operations. A typical example consists of intra-logistics operations, such as delivering light components, spare parts or tools. Finally, "transform" is the ability of a drone system to collect data and transform them into information while performing physical operations (e.g., carrying objects). It combines the capabilities of "see", "sense", and "move". The simultaneous implementation of these three capabilities introduces major challenges of cooperation, analytics, information processing, and optimization, all of which are control-centric in nature and require innovative tools. Indeed, current examples of "transform" in the logistic scenario are scarce and in the related literature few contributions rely on this category. Bridging this gap is exactly the objective of the present project.

Thanks to drones' ability to fly and hover autonomously, avoid obstacles in different layouts, navigate indoor and outdoor, land precisely and potentially operate in fleets, the use of DaaS will have a great impact on several aspects of companies specialized both in internal and external logistics. In particular, this project will

focus on the most promising areas of indoor drone services in warehouses 4.0, which are inventory management, intra-logistics of items, as well as inspection and surveillance and on the integration of outdoor drones' services in urban areas and delivery networks. To this aim, decision and control techniques for mission and path planning, collision avoidance, synchronization, formation tasks for surveillance, tasks for coordination with ground vehicles and platforms will be implemented for drones and fleets of drones operating in complex environment. All these features constitute a challenging problem for control engineering and robotics with numerous applications.

UAVs and networks of UAVs are a fruitful ground for control systems' research, as their dynamical nature and under-actuated configuration make it ideal to synthesize and analyze control algorithms. In fact, over the last two decades, several research studies have focused on the guidance, navigation, and control for drones and fleet of drones, resulting in various techniques and methods that are organized according to the above categories (i.e., guidance, navigation, and control). For each category, methods are grouped at the highest level based on the autonomy level they provide, and then according to the algorithmic approach implemented, which in the majority of cases is closely associated with the type of sensors used.

Therefore, in order to make drones-based services part of modern daily life, the main contribution of this PhD project will be the development of complex control platforms within warehouse management and external logistics that integrate the control techniques studied in the related literature with innovative solutions addressing the interaction with human workers (human-drone interaction). Indeed, focusing on the improvement of operator's safety and well-being and on the increase of flexibility and productivity as well as efficiency of industrial processes, the use of drones can lead to a reduction of the production downtime and of the labor turnover.

With the aim of combining the drones' capabilities of see, sense and move, this research will define new decision and control techniques for the use of DaaS in warehouses and external logistics. The expected results will be focused on the development of new control architectures and frameworks for path planning and collision avoidance ("move") using on-board sensors in both structured and dynamically changing environments ("see") without relying on external infrastructure, such as GPS or motion capture systems and implementing algorithms which are able to identify any anomalies ("sense") within the warehouse and urban delivery management (e.g., loss of items). In this way, drones are able to actively navigate and collaborate with operators in both indoor and outdoor environments extracting the best knowledge from them.

D.M. 351/2022
Area: NRRP
Topic: "SANI - Development of sustainable anti-microbial nanomaterials for innovation in the food industry"

Research Proposal - ABSTRACT:

The PhD project aims to design, characterize and implement nanomaterial-based treatments with synergistic action to combat the formation and/or growth of biofilms of interest in the food industry.

Various pathogenic microorganisms (e.g., bacteria, fungi) can grow during the processing of a food product or directly on it resulting in the formation of biofilms (colonies immersed in a matrix of polysaccharides, proteins and exogenous DNA).

These are capable of significantly adhering and growing on a variety of surfaces (from steel to fruit peels) rendering conventional sanitization/disinfection processes (e.g., hypochlorite, quaternary ammonium salts) ineffective.

Problematic examples of pathogens in the food industry include Lysteria monocytogenes and Salmonella enterica as they can cause serious illness to humans up to and including death. According to EFSA (European Food Safety Agency) in 2019, more than 2,500 cases of listeriosis were confirmed in Europe with mortality over 17 percent, while salmonellosis affected 88,000 cases. Therefore, it is also crucial to invest in the research and development of innovative systems of use in the processing and packaging stages of food for its safety as well as for the disinfection of work surfaces by taking advantage of sustainable and low-impact processes.

In fact, another important aspect in this area concerns the possibility of making the new antimicrobial nanomaterials inspired by the principles of Green Chemistry thus pursuing the objectives of the European Green Deal. In this regard, synthesis strategies based on the use of scalable and low-cost aqueous-phase processes (e.g., electrochemical type) will be developed for the realization of synergistic-acting nanoantimicrobials by exploiting environmentally friendly and low-toxic chemical precursors with a propensity for zero-waste approaches. Nanostructures (NS) of metals (Cu, Ag) and metal oxides (ZnO, MgO) and their combinations will be realized in combination with additional agents with known antimicrobial action of natural origin (e.g., lysozyme, chitosan) for the realization of coatings in the form of thin films and/or nanocomposites for the modification of food packaging as well as work surfaces.

The involvement of the foreign partner (University of Balearic Island, PI: Professor Manuel Mirò, with whom a joint investigation on interactions between nanoantimicrobials and liposomes is already underway) will allow the evaluation of the effectiveness of the proposed new technological solutions in specific case studies, thus representing an added value for the doctoral student's training both in terms of internationalization and applied research.

The proposed pathway has a significant interdisciplinary character by placing itself at the intersection of chemistry, industry and process innovation intercepting not only the "education and research" mission of the PNRR, but also that of the green revolution. The project will thus enable the training of a qualified professional with cross-cutting skills from materials science, analytical chemistry, microbiology to food

process technology making the acquired know-how expendable in different working fields, primarily in food quality and safety. In addition, the proposer's research group has many years of experience in the field of nanoantimicrobials for applications in the agrifood industry, as also evidenced by the recent funding of a PON Industrial project "ProFood IV. Innovative products and processes for the IV fruit and vegetable supply chain." This project may provide an additional source of co-funding for this doctoral program as well as an opportunity for the doctoral student to collaborate with other research and business partners in the industry.

Topic: "Development of AI-based advanced control strategies for urban mobility"

Research Proposal - ABSTRACT:

The goal of this PhD project is to study, develop, and test advanced artificial intelligence-based control strategies for complex systems and subsystems concerning how people and goods move in a smart city.

In particular, the project aims to improve the resilience of the transportation system with respect to its fragilities and possible degradation, improving safety and reducing environmental impact. In addition, the project aims to achieve the digital transformation of infrastructure networks for more integrated, efficient, safe and secure mobility. Finally, the project aims to prepare transportation networks for the inflow of connected and automated vehicles by developing innovative control strategies for fleets of connected and automated vehicles and/or smart infrastructure and by developing robust control strategies for fleets of connected and automated vehicles, smart infrastructure, and unconnected vehicles.

Specifically, the project will study and implement artificial intelligence and deep reinforcement learning technologies applied to both the modeling and control of automated and connected vehicles and the modeling, control, and management of smart infrastructure connected to people and vehicles (traffic lights, parking lots, lighting, pavement, etc.). Deep reinforcement learning is a trial-and-error learning method that needs a simulation environment to train the agent's policy that will perform certain tasks. After training, the agent will be able to make the best decisions by using only the previously adjusted policy and sensor readings. To achieve good training of the agent's policy, the simulation environment must faithfully reproduce the behavior of the real system either through concrete models or through abstract models that reproduce reality using computers.

The proposed project creates high added value in scientific terms as it will develop artificial intelligence and deep reinforcement learning technologies that can be used in various industries. On the other hand, the innovative techniques of artificial intelligence and deep reinforcement learning have great spin-offs in economic terms as they tend to replace the time-consuming and costly work of calibrating models done almost manually today with automatic techniques based on digital algorithms.

From the social point of view it determines a new culture with the enhancement of human capital by determining the development of professional profiles based on the digitization of industrial processes in an Industry 4.0 perspective.

The research is framed within the vision of the Horizon Europe 2021-2027 framework program that outlines research priorities to support sustainable recovery by further accelerating the dual green and digital transition and the PNRR that aims to implement the strategic mission of the digital transition.

In the area of mobility, a key emphasis is placed on the digitization of transport focusing on automated mobility.

GRANT N. 4
DRI 4.0

D.M. 352/2022
Co-funded by: Manta Group s.r.l.

Topic: "Energy flexibility using storage systems for industrial buildings"

Research Proposal - ABSTRACT:

Heating, ventilation and air conditioning systems for building has long been engaged in the search for technologies capable of providing greater energy efficiency and flexibility. Direct electrification and combined heat and power (CHP) are among the most widely pursued approaches to encourage a significant reduction in the environmental and economic impact of the energy demands of buildings, and particularly factories. However, the seasonality of heat demand, the increasing demand for cooling, and the variability and limited capacity of renewable electricity supply are significant constraints that limit activities in buildings, such as factories, that are often constructed without any attention to energy conservation. Within this framework, there is a growing focus on building electrification coupled with the use of energy storage systems and the coupling of solar energy with thermal storage to reduce a building's energy demand. This is evident in Cluster 5 "Climate, Energy and Mobility" of the Horizon Europe program dedicated to developing solutions for sustainable energy production, use and storage.

With building electrical demand becoming increasingly significant and an increasing proportion of intermittent renewable generation from solar PV, often adopted heavily in industrial clusters where there is ample roof space, there are new opportunities for energy networks in industrial clusters willing to face growing challenges in managing the balance between supply and demand and local district energy production/distribution. In this scenario, a smart response to energy demands that can promote thermal and electrical energy storage also in order to promote energy demand flexibility in the industrial sector is receiving increasing attention.

This project focuses on different modes of energy storage, both electrical and latent, the operation of which will be implemented through the use of IoT systems and connection with enterprise management systems. The case study will be represented by the partner company in this project, the MANTA GROUP. This company has developed an interest in energy storage technologies that promise more flexible management of its energy demand, with the understanding that having energy flexible buildings is essential for a reliable and resilient power grid, especially in factories such as those of MANTA GROUP where minimal variability in indoor temperatures and humidity levels is required. Such demands result in significant energy costs, which can be alleviated through distributed renewable generation and energy storage, capable of improving the energy stability.

GRANT N. 5
DRI 4.0

D.M. 352/2022
Co-funded by: Hevolus s.r.l.

Topic: "Tools and methods to make the Metaverse accessible to Italian SMEs and others "

Research Proposal - ABSTRACT:

With the spread of smartglasses predicted by analysts, the Metaverse will soon be the leading social platform for integrating the real, virtual and mixed worlds (Virtual, Augmented and Mixed reality). This fascinating new paradigm unveils a series of unexplored opportunities in various fields of user experience, applications, product and service personalization, and transportation and waste reduction. However, the Metaverse, also poses a danger to those who cannot handle its tools and methodologies or who simply cannot afford the cost of accessing it. In addition, the Made in Italy sector that focuses on quality and emotional product and will have to find effective forms of expression to express itself through these new channels and tools.

The research in coherence with the National Strategy "Industry systems and applications for attractiveness of Made in Italy" in aims to speed up and simplify access to the Metaverse especially by SMEs and microenterprises.

The main activities will be the Metaverse study from a theoretical point of view with the aim of identifying and formalizing its criticalities both from a software and hardware systems point of view, related interfaces and accessibility limitations. Methodologies and tools for building high-impact and easily customizable Metaverse environments will be explored. The methodologies will be validated with case studies can selected companies with scientific metrics (SUS, NASA TLX).

The research has a high degree of Innovation from both a scientific but also an industrial perspective. The expected results are an advancement of knowledge on these new channels, publishable in international journals and conferences, but also competitively with the development of methodologies, algorithms and proprietary applications possibly patentable.