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

Attachment 2

PhD PROGRAMME IN ELECTRICAL AND INFORMATION TECHNOLOGY ENGINEERING

Project Identification Code (CUP): D93C22000490001; D93C22000510001; D93D22001320001

XXXVIII CYCLE DOCTORATE PROGRAMME PROFILE	
DEPARTMENT	Department of Electrical Engineering & Information Technology
COORDINATOR	Prof. Mario Carpentieri (mario.carpentieri@poliba.it)
PLACES AVAILABLE	25
of which	
Places with Politecnico di Bari grant	3
*Places with **Politecnico di Bari grant reserved for graduates from non-Italian universities***	1
*Places with grant funded by NRRP – as per Ministerial Decree **351/2022*** ***Refer to research topic list below***	5 of which: GRANT N.1 - **Area:** NRRP; **Topic:** *"Advanced systems for precision diagnosis and treatment of visual apparatus pathologies";* GRANT N. 2 - **Area:** PNRR; **Topic:** *"Planning and implementation of an optical interferometer integrated within SOI technology";* GRANT N.3 - **Area:** Public Administration; **Topic:** *"Smart and innovative solutions for sustainable mobility in self-driving vehicles";* GRANT N. 4 - **Area:** Public Administration; **Topic:** *"Design and evaluation of novel Lawful Interception architecture and tools for Beyond 5G networks";* GRANT N. 5 - **Area:** Digital and Environmental Transition; **Topic:** *"Development of a technological platform of microwave and optical devices for the telecommunication of the future".*
*Places with grant funded by NRRP – as per Ministerial Decree **352/2022*** ***Refer to research topic list below***	8 of which: GRANT N. 6 - **Co-funded by**: Applica s.r.l..; **Topic: "***Development of advanced monitoring strategies based on AI for collaborative robotics";* GRANT N. 7 - **Co-funded by**: Martur Italy s.r.l.; **Topic: "***Development of AI applied to computer-aided engineering, the metaverse for car industry production processes and machine learning";* GRANT N.8 - **Co-funded by**: Esaote s.p.a.; **Topic: "***New generation digital gradient amplifiers for MRI";* GRANT N.9 - **Co-funded by**: Metasensing s.r.l.; **Topic: "***Real-Time Ship Detection on satellite SAR data";* GRANT N.10 - **Co-funded by**: Northrop Grumman Italia s.p.a.; **Topic: "***An interferometric optic fibre gyroscope for cost-sensitive applications";*

	GRANT N.11 - **Co-funded by**: N.P.C. New Production Concept s.r.l.; **Topic: "***Development of a high-performance On-Board Computer for nanosatellite platforms";* GRANT N.12 - **Co-funded by**: Tesmec Rail s.r.l..; **Topic: "***Reliable, smart and green propulsion control of construction and maintenance railway vehicles";* GRANT N.13 – **Co-funded by:** Arol s.p.a.**; Topic:** *"AI and intelligent control for innovative closure and capping systems in the food and beverage industry".*
*Places with **externally** funded grant*	2 of which: **GRANT funded by:** Cortus s.r.l.; **Topic: "***Study and planning of integrated programmable structures for the monitoring of transceiver stacking ";* **GRANT funded by:** Rete Ferroviaria Italiana (RFI); **Topic:** "*Analysis, production and integration of on-board subsystems for Speed Monitoring and Odometry for ATO over ETCS STM Board*".
Places without grant funding	6
ADMISSION REQUIREMENTS *Applicants to the PhD programme in Electrical and Information Technology Engineering **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].

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)**.

[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.*

Candidates with qualifications awarded in Italy must 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).

  (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

[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/".

	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 B_FORMAT PROPOSTA DI RICERCA_DRIEI.doc*"):** **https://www.poliba.it/sites/default/files/dottorati/allegato_b_format_proposta_di_ricerca_driei_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 the applicant's aptitude for research and willingness to undertake experience abroad, as well as areas of research interest.
DATES OF INTERVIEWS	Tuesday 13 Sept 2022;

	Wednesday 14 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

GRANT N. 1
DRIEI

M.D. 351/2022
Area: NRRP

Topic: "*Advanced systems for precision diagnosis and treatment of visual apparatus pathologies*"

RESEARCH PROPOSAL:

In Europe, communicable and non-communicable diseases account for up to 80% of EU health costs. Most of these costs are used to treat diseases that are largely preventable. Another important fact is that only 3% of the European health budget is currently spent on disease prevention measures, although there is enormous potential for optimal prevention measures.

To improve this context, there is an urgent need for research and innovation in order to develop new preventive measures, diagnostics and precision therapies, and to improve existing prevention strategies. This objective is not only aimed at improving the social environment in which the citizen is placed, but also at improving and strengthening patient safety.

The above data are also confirmed by the World Health Organization, which has declared that the challenge of medicine in the Third Millennium is represented by the right to sight, having estimated more than 161 million people suffering from pathologies of the visual apparatus. Italy is also at the forefront of this project, having established a National Commission for the prevention of blindness, one of the diseases that affects the population most.

A careful analysis of the current structure of the assistance for the visual apparatus has evidenced the persistence of important criticalities attributable to the marked territorial inhomogeneity in the distribution of the beds and the ambulatory services and to the fragmentation of the case studies at many bidding points, with not optimal response for some pathologies of considerable importance and complexity. Therefore, introducing a system that can monitor the patient's state of health without hospitalization reduces these critical issues and at the same time limits the cost of medical services to citizens.

As a result, there is a growing interest in the development of advanced systems for the preventive diagnosis and precision treatment of pathologies of the visual system.

The research activity is based on the implementation of enabling technologies to create advanced tools for the early diagnosis of diseases inherent in the patient's visual system, aimed at the timely precision treatment of such pathologies. In this context, the availability of clinical data and images obtained using high frame rate cameras as well as computational tools with high computational capacity will allow the implementation of image processing algorithms that improve reliability and the efficiency of algorithms already present in the literature for the early diagnosis of diseases of the visual system.

In addition to a purely scientific impact, research will also have strong social and economic consequences. In fact, this activity will drastically reduce the social inequality in the territory on access to public health, will

eliminate the problem of territorial inequality in the provision of outpatient services. Moreover, this research will make it possible to minimise public expenditure on medical services to citizens, with obvious economic benefits. The integration of these advanced devices for the diagnosis and prevention of pathologies will allow to create a company Healt 5.0, in which health care is focused and personalized according to the patient being examined, enabling citizens to have equal access to the health services offered by their state.

Therefore, the proposed research activity will contribute (in accordance with the aims of Horizon Europe 2021/2027 Cluster 1) to the development of a new professional profile able to provide medical assistance remotely centralized and personalized according to the patient under examination, encouraging the exchange between technological development and medical research, while playing a key role in the digital transformation of society supported by the introduction of advanced biomedical systems.

The aim of the research theme is to develop and validate new technologies for the early diagnosis of the main pathologies concerning the human visual system. This research theme is highly multidisciplinary: in order to implement this advanced diagnostic system, it is necessary to use: skills in the design and characterization of measurement systems; computer skills, image processing algorithms useful for interpreting and extracting information from them to the use of neural networks and machine learning to make a classification of the different pathologies identified in the human visual apparatus; electronic skills for the hardware development, from the choice of the construction parameters of the camera to be used to the physical realization of the prototype of such advanced system; as well as biomedical skills for the clinical validation of data.

The proposed system involves the use of image sensors to output a succession of images related to the visual apparatus of the patient under examination. For the validation phase it will be necessary to acquire a certain amount of data from patients with different visual pathologies using the prototype system. By applying image processing algorithms on this database, it will be possible to process the frames available for each patient, allowing to detect any pathologies of the visual apparatus of the patient under examination. Once the first objective of identifying the pathologies present in the patient's visual system has been reached, it will be necessary to use a machine learning algorithm to classify any different pathologies present.

Part of the research will be conducted in collaboration with the university and health facilities of Maryland, both for the collection of additional clinical data, both for the validation aspects of the proposed prototype system by means of a comparison between the patient's medical record and the diagnostic system output. It will also be possible to identify the precision therapy that can attenuate, slow down or completely eliminate the diagnosed visual pathology, and monitor the outcome of therapy. Several innovative therapies based on laser technology are mentioned in the literature. In particular, near-infrared laser therapy (NIR), or photobiomodulation therapy (PBMT), is widely applied in the experimental field, following significant progress in the fields of photobiology and bioenergetics, in which the benefits of such therapy for the treatment of visual pathologies have been demonstrated. Collaborations are also planned with the École Polytechnique Fédérale de Lausanne (EPFL) for the development and prototyping of biosensors for the monitoring of biological signals and physiological parameters of the visual apparatus, and with the company ivis Technologies s.r.l., company specializing in the diagnosis of corneal diseases and corneal surgery.

GRANT N. 2
DRIEI

M.D. 351/2022
Area: NRRP

Topic: "*Planning and implementation of an optical interferometer integrated within SOI technology*"

RESEARCH PROPOSAL

Spectroscopy is of fundamental importance in several sciences, ranging from Physics to Chemistry, from Medicine to Biology. However, high-resolution, low-cost, low power, wide-wavelength-range, integrated optical spectrometers are still object of research. Typically, bulk Fourier Transform Infrared (FTIR) spectrometers are located in dedicated laboratories. However, the robustness of these systems is often compromised by fragile mechanical moving parts or stringent optical alignment requirements. In this context, on-chip photonic integration offers an attractive and very promising solution to overcoming the aforementioned limitation, where a broadband source is used in conjunction with an integrated spectrometer, to process the wavelength-dependent absorption or the index change in the device sensing element. Moreover, planar photonic integration further opens up the possibility of a strong cost reduction leveraging standard high-volume semiconductor manufacturing processes (Silicon on Insulator, SOI) for applications such as consumer electronics or sensor networks for the internet of things (IoT). An integrated optical spectrometer would enable the possibility of detecting spectral signatures of analytes in liquid (water or other) or in air on the basis of their absorption or index change spectrum, thus allowing high-performance and real-time monitoring in advanced sensing applications to be used in environment or biomedical. A broadband source can be used to illuminate the sample in the wavelength range where the spectral signatures of analytes are expected to be, so that the spectrometer can distinguish the various substances. This can be accomplished via a waveguided optical absorption cell (in Fig. 1a), interacting with the analite in the solution. For example, a Mach-Zehnder interferometer, appropriately functionalized for specific analytes in the sensing arm with respect to the reference arm, can be considered operating as an absorption or index change region in a microfluidic flow, using a broadband source and an Arrayed Waveguide Grating (AWG) for light demultiplexing with a photodetector array (see Fig. 1b). To further improve the sensitivity of this device for detecting trace analytes, a ring resonator can be included in cascade to have a Vernier effect, so improving the limit of detection (LOD) of at least two-three orders of magnitude that of the basic configuration without Vernier.

Figure 1 – a) Layout-on-chip; b) Mach-Zehnder interferometer with AWG.

A valuable figure of merit for an integrated optical spectrometer is given by the maximum scannable wavelength range which, together with the resolution, characterizes the device. In general, a wide scanning wavelength range is required for simultaneous detection of different spectral features of several analytes in the absorption cell. But, at the same time, a high resolution is needed, in order to be able to distinguish very narrow spectral signatures of different analytes in the same polluted environment.

At the state of the art, a typical trade-off between resolution and wavelength scanning range is the need in the design of integrated optical spectrometers. The limiting factor is the scalability of the spectrometer. For

example, the AWGs are well-known wavelength-dispersive components, largely used for realizing spectrometers. However, trying to realize wide-wavelength-range and high-resolution with AWGs would make it necessary to increase the number of photodetectors needed, up to the limit of effective integrability. Other possible solutions for high resolution and, at the same time, wide wavelength ranges could involve the use of AWG with tunable ring resonators to simultaneously exploit the high resolution of ring resonators and the wide wavelength range of AWGs. Another very elegant approach could use a multiple-path grating Michelson interferometer, where the optical path is controlled by the thermo-optically (TO) induced wavelength shift in the TO modulators of the architecture shown in Fig. 2. This last architecture of the spectrometer should be very suitable for the spectrum reconstruction of an unknown signal by the recombination of the spectrograms generated by the device. The applications can involve the automatic signal equalization in sophisticated telecommunication optical networks.

The final implementation of device, which will be studied, fabricated and characterized during the PhD course, will use a wideband source to illuminate from outside the spectrometer chip, a sensible region which could be functionalized to detect specific analytes and a photodetection region based on a photodiode array or on a single photodetector, depending on the selected final solution. The fabrication of the integrated spectrometer will be carried out in collaboration with the Optoelectronics Research Centre (ORC) of University of Southampton, world-renowned research center and at the forefront in the field of Group IV Photonics, where the PhD student will be involved (for a total period of at least 12 months) for the device fabrication as well as the optical and electrical characterization. The PhD course will be completed with the experimental demonstration, at the proof-of-concept level, of the selected integrated spectrometer, that in Fig. 1b or Fig. 2, in standard Silicon-on-Insulator (SOI) technology.

Figure 2 – Principle scheme of integrated optical spectrometer based on Michelson interferometer.

Shortly, the PhD student activity will be organized as follows:

1) Study of the state-of-the-art of integrated optical spectrometers
2) Design of selected architecture and layout definition
3) First run of fabrication in SOI technology at ORC (three months)
4) Optical and electrical characterization at ORC (three months)
5) Comparison between theory and experimental results
6) Improvement of design parameters and layout for the second run of fabrication
7) Second run of fabrication at ORC (three months)
8) Optical and electrical characterization at ORC (three months)

REFERENCES

1) Soref, R.; De Leonardis, F.; Passaro, V. Scanning Spectrometer-on-a-Chip Using Thermo-Optical Spike-Filters or Vernier-Comb Filters. Journal of Lightwave Technology 2019, 37, 3192-3200, doi: 10.1109/JLT.2019.2912725.

2) Soref, R.; De Leonardis, F.; Passaro, V.; Fainman, Y. On-Chip Digital Fourier-Transform Spectrometer Using a Thermo-Optical Michelson Grating Interferometer. Journal of Lightwave Technology 2018, 36, 5160-5167, doi: 10.1109/JLT.2018.2867241.

GRANT N. 3
DRIEI

M.D. 351/2022
Area: Public Administration

Topic: "*Smart and innovative solutions for sustainable mobility in self-driving vehicles*"

RESEARCH PROPOSAL

The goal of the PhD program is to study, develop and test intelligent and innovative solutions for cooperative, connected and automated mobility (CCAM), based on artificial intelligence, machine learning and deep reinforcement learning.

The research is part of the vision of the Horizon Europe 2021-2027 framework program which illustrates the research priorities to support sustainable recovery, further accelerating the double green and digital transition and of the PNRR which intends to implement the strategic mission of the digital transition. In the mobility sector, fundamental importance is given to the digitalisation of transport, focusing on automated mobility.

The research topic is compliant with the SNSI since it takes place in the Digital Agenda, Smart Communities, Intelligent Mobility Systems thematic area and will use solutions based on information and communication technologies, such as Connected and Cooperative Services, Artificial Intelligence and Big Data that allow users, vehicles and infrastructures to be connected in an intelligent, efficient, safe and sustainable way. In addition, Machine Learning and Deep Reinforcement Learning architectures along with optimization techniques will be used to carry out research activities in some of the thematic areas of the CCAM, such as motion planning, vehicle tracking, pedestrian detection, traffic sign detection, road marking detection, automated parking, vehicle IT security and fault diagnosis.

Furthermore, the research is part of Cluster 4 of the Digital, Industry and Aerospace PNR pursuing the following objectives:

OB4: Consolidate and enhance reliable digital and emerging technologies. In fact, it will enhance the scientific and technological skills and excellence in the key mobility sector with the use of artificial intelligence solutions.

OB7: Strengthening the industry-research ecosystem and technology transfer. The project will strengthen innovation and the exchange between research and the industrial world through close collaboration with research centers and companies involved in the Horizon Europe IN2CCAM project (beginning 1 November 2022 - end 31 October 2025) coordinated by the Polytechnic of Bari in the CCAM area.

The consequent impacts will be:

IMP6: Definition of an inclusive society in the use of technologies for the individual and for the development of the economy, optimizing their use and minimizing their risks.

IMP8: Improvement of industry-university relations and creation of a virtuous circle of skills transfer.

Finally, the research falls within the Horizon Europe and Green Deal program and in particular in the priority Industry and Green Deal, An industrial strategy for a competitive, green, digital Europe, in which the general vision is that of a Europe that designs and develops technologies competitive and reliable for industry and mobility, based in particular on artificial intelligence and the digital transition.

In particular, the following objectives will be pursued:

• **Objective 1:** To determine the concepts of traffic management in the CCAM ecosystem in order to optimize the mobility of people. To this end, social and individual needs and requirements will be taken into account (also considering age, gender, social level and disability) in order to guarantee safety, sustainability and inclusiveness. The main objective will be to identify and agree on a minimum set of adaptations necessary on the infrastructural side to support CCAM in mixed traffic.

• **Objective 2:** Design, build and test the physical and digital infrastructural intermodal interfaces between the platforms of the CCAM ecosystem for fleet and traffic management, also implementing services for interoperability in multimodal transport systems.

• **Objective 3:** Design, implement and test advanced simulation and digital twin models in order to evaluate new traffic management strategies for CCAM.

• **Objective 4:** Designing adaptive strategies for optimizing traffic and balancing flows based on real-time traffic intensity, on the forecast of traffic situations in the immediate future and on the adaptation of green times in line with the volume of traffic in real time, also involving users in real time.

The research will consist of the following phases:

Phase 1. In the first phase, an analysis of the state of the art will be carried out on artificial intelligence and deep reinforcement learning (DRL) techniques that can be used within the CCAM. Furthermore, the Artificial Neural Network (ANN) techniques will be studied for the realization of the identification and diagnosis strategies of faults. For the implementation of the solutions, optimization techniques based on consensus protocols that can be implemented in real time will be studied.

Phase 2. In the second phase, the studies carried out in the first phase on artificial intelligence will be used to propose innovative solutions for the optimized choices of urban routes to balance traffic and reduce congestion. Optimized techniques for the detection of pedestrians and road signs will be applied and vehicle-vehicle and vehicle-infrastructure consensus algorithms will be studied for the control and management of vehicles at intersections, using any platooning techniques.

Phase 3 In the third phase of analysis and validation (also carried out abroad and in the company), a framework for impact assessment will be prepared, based on KPIs to measure the performance of the solutions and their impact on the CCAM ecosystem. Methods and specific test environments will be proposed that include a CCAM simulation tool to test the interoperability of end-to-end communication. In addition, the analysis of real traffic conditions will be simulated using advanced simulation models and tools and real-world data to predict the applicability of the proposed techniques in large-scale traffic systems. Test tests can also be envisaged in living lab optics with the cooperation of the research centers and companies involved in the IN2CCAM project.

Phase 4 This phase of publication of the results will be temporally simultaneously with the others with publications both at international conferences (IEEE SMC, IEEE CDC, IEEE CASE, IEEE ICRA, IFAC Conferences) and in international journals of the sector (IEEE Trans. On Automatic Control, IEEE Trans. On Automation Science and Engineering, Control Engineering in Practice, IEEE Trans. On Control System Technology).

GRANT N. 4
DRIEI

M.D. 351/2022
Area: Public Administration

Topic: "*Design and evaluation of novel Lawful Interception architecture and tools for Beyond 5G networks*"

RESEARCH PROPOSAL

The context

In the EU, over 80% of criminal networks are involved in cybercrime, illegal drugs trade, illegal firearms and explosives trade, environmental crime, fraud and scrams, counterfeiting, crimes against people, etc. During 2020, 57 terrorist attacks were handled in EU member states, in which 21 people were killed, and about 450 arrests were executed because of suspicion of terrorism-related offense [ES21]. To prevent, detect, and investigate these criminal and terrorist offences Law Enforcement Authorities (LEAs) daily exploit Lawful Interception (LI) techniques and methodologies. At the same time, the massive diffusion of new and emerging technologies (mainly 5G and Beyond communication systems and end-to-end security) is rapidly weakening the effectiveness of conventional approaches, thus posing challenging questions to address alongside computer science, technology, standardization, and regulation domains (interdisciplinary issue!). This is fully confirmed by a recent Europol report [EU19a], which highlighted the main drawbacks introduced by 5G and Beyond communication systems: (i) encryption of the IMSI makes current IMSI catchers obsolete, (ii) network slicing brings to data fragmentation, impossible to capture with 3GPP and ETSI standardized approaches, (iii) Multi-access Edge Computing (MEC) makes conventional LI architectures, working in the operator's core network, ineffective, (iv) application-level or TLS-based security protocols, commonly used to protect end-to-end communications, require the usage of disruptive mechanisms able to manage encrypted traffic. All these research challenges are of interest of many PNRR initiatives, as indicated by "Linee guida per le iniziative della missione 4 – componente 2" and its descriptions of "Cybersecurity" and "Telecomunicazioni del Futuro" topics to be covered by "Partenariati Estesi" initiatives.

[ES21] European Commission - Eurostat, Recorded offences by offence category - Police data, 2021.

[EU19a] Council of the European Union, EUROPOL, 'Position paper on 5G', April 2019.

Objectives and methodology

Considering these challenges, the Ph.D. student will address an important research activity willing to achieve the following main objectives.

1. Define a new LI architecture for 5G and Beyond communication systems.

The research program will focus the attention on a heterogeneous and cross-border 5G and Beyond communication system, where multiple networks are deployed and controlled by different infrastructure

providers. Each infrastructure provider exposes its resources to various service providers. The infrastructure provider has the control of its own resources, via Software-Defined Networking (SDN) facilities. The service provider, however, can manage the (virtual) resources shared by the infrastructure providers for offering their vertical services, according to the network slice and MEC paradigms. In such a complex ecosystem, end users can attach to the network via heterogeneous access technologies and enjoy heterogeneous services offered by multiple virtual service providers concurrently exploiting the underlying infrastructure, thereby setting-up a multi-tenant, multi-domain and heterogenous 5G and Beyond communication system. Thus, users can generate and/or receive - potentially at the same time! - data streams, delivered across multiple network slices expanded end-to-end between cellular and non-cellular networks, and directed to/ended by MEC entities, remote clouds, or any other remote server/user. Here, the Ph.D. student will define a new LI architecture operating in a complex infrastructure where several virtual service providers offer, across borders and organizations, advanced services through MEC and network slice paradigms. Indeed, advanced management functions (like the dynamic orchestration of POIs) and interception mechanisms will be designed and developed to intercept data from both edge and high-speed core networks.

2. Provide new effective methodologies and tools for traffic and data analytics.

To cope with end-to-end encrypted traffic flows, the Ph.D. student will conceive and develop a set of traffic and data analytics tools able to process, also in real-time, the heterogeneous intercepted data, collected by operator-assisted or stand-alone methodologies. These tools will have the major objective to extract knowledge (e.g., network activity, service type, user behaviour) from collected heterogenous data through AI-based algorithms and fundamental further chances to detect and investigate criminal and terrorist offences. In general, traffic and service classification on encrypted data will be performed by using one or more of the recent powerful AI-based methodologies, like Sparce Auto Encoder, Long Short-Term Memory, 1D and 2D Convolutional Neural Networks, or hybrid approaches. To cope with data fragmentation introduced by the network slice and MEC paradigms, and security concerns related to the access to sensitive retained data within the heterogeneous 5G and Beyond communication systems, the Ph.D. student will also explore solutions based on distributed learning, such as Federated Learning.

Work organization and usage of solid scientific instruments

The activities of the Ph.D. student will be planned throughout 5 partially overlapped phases (for each phase is reported starting/ending Month):

1) Analysis of requirements, reconnaissance of pilot experiences and review the scientific state of the art (M1-M6),

2) Characterization of Beyond 5G and Lawful Interception technologies (M4-M12),

3) Design of novel methodologies and innovative Lawful Interception architectures and techniques (M9-M30),

4) Performance analysis (through hybrid, open source, and event-driven simulators and testbeds, based also on analytical models) and refinement of proposed solutions (M12-M33),

5) Dissemination of outcomes (M7-M36).

During these phases, the Ph.D. student will use the major scientific equipment (or sets of instruments), archives or scientific data, and computing and software systems available at the DEI department (mainly, Telematics Laboratory) of Polytechnic University of Bari. These includes world-renowned scientific software such as Matlab, digital libraries such as IEEEXplore, and high-performance computing workstations.

Interdisciplinary approach and collaborations

The overall research program will explicitly require an interdisciplinary approach and competencies (spanning among networking, security, safety, ethical, and legal). Indeed, it will surely promote the definition and/or the consolidation of national and international collaborations with other research institutions. To this end, it is important to highlight that Prof. Piro is currently involved in several national (UNIROMA2, UNIGE, TIM, VODAFONE) and international collaborations (CTTC, HKBU, WINGS, TELEFONICA) connected to the topic of interest of this proposal.

Dissemination activities and impact

To give visibility of the main architectural and scientific achievements (including research vision, the general architecture, and solutions and techniques for interception of offenses, crimes, and attacks), the Ph.D. student will consider the following academic venues: international conference, such as IEEE ICC, GLOBECOM, INFOCOM, PIMRC (KPI: > 1 per year), high-profile journals, such as IEEE TNSM, Elsevier Computer Networks, IEEE/ACM TON, IEEE TWC, Elsevier Ad-Hoc journals, IEEE COMLET and IEEE WCL (KPI: about 2 for the 3 years), iii) publications in magazines targeting multidisciplinary discussions, such as IEEE Communications Magazine; IEEE Wireless Communications Magazine (KPI: 1 during the overall period).

When possible, scientific works will be published via *Open Access*. Or shared in pre-print versions through academic websites. Produced datasets will be shared according to the *Findable, Accessible, Interoperable, Reusable (FAIR) principle*, by using for example

Zenodo or IEEE dataport.

At the same time, research activities of the Ph.D. student will produce *several contributions* alongside the following items.

1. Scientific contribution. In line with EU expectations on that topic, as well as PNRR objectives, the Ph.D. student will develop novel tools for Lawful Interception activities that go beyond the current state of the art.

2. Technological and economic contributions: Obtained results will be presented to national and international stakeholders (also by sustaining deep collaboration with the industry and, if possible, to Police Authorities), thus increasing their interest to invest in hard development activities and obtain a faster time to market.

3. Societal contribution. Without any doubts, the scientific, technological, and economic impacts will guarantee the birth of new approaches to safeguard the civil rights of EU Citizens and reinforce the whole-of-society approach to security, needed to guarantee the respect of fundamental rights of the society.

GRANT N. 5
DRIEI

M.D. 351/2022
Area: Digital and Environmental Transition

Topic: "*Development of a technological platform of microwave and optical devices for the telecommunication of the future*"

RESEARCH PROPOSAL

Project objective

The project aims to develop an example of a technological platform consisting of innovative optical and microwave devices for future communications, with a focus on medium infrared (Mid-IR) WDM techniques and microwave devices, millimeter wave and sub-terahertz. The new optical devices in the Mid-IR, based on innovative glasses, such as fluoride, fluorindate and chalcogenide, doped with rare earth, will allow communication in the window 3-5 µm, with the aim of finding a solution to be integrated with millimeter wave antennas. Innovative antennas, for Massive Multiple-Input-Multiple-Output (MIMO) applications, beam-forming and beam-steering, can be designed through professional software, constructed and characterized thanks to the equipment available at the laboratory of Microwave and Optical Engineering (MOE) of Bari and at the Interdepartmental Center "Magna Grecia" of Taranto.

The thematic is fully included in the objectives of the "Piano Nazionale di Ripresa e Resilienza (PNRR)", especially for the telecommunications of the future, paving the way for applications in the field of communications, environmental sensors and biomedical, Internet of Things (IoT)

Research project summary

The telecommunication of the future is a topic of great interest, aimed at increasing the speed of transmission, to ensure, for an increasing number of users, the use of multimedia services. The Internet of Things (IoT) provides for communication between different devices, allowing remote sensing in different areas (environmental, biomedical, industrial) and their remote control. This Machine-to-Machine connection (M2M) needs high bit-rates, secured via fiber optic transmission and frequently, in the terminal part of the communication channel, via free propagation links (wireless). In addition, fiber optic technology allows not only data transmission but also the realization of sensors integrated in the network. For example, efficient environmental monitoring and industrial process sensors can be made from passive or rare earth doped fiber optics in the window 3-5 µm, in which many molecules show an absorption of infrared radiation providing their spectral signature. These wavelengths can be reached using new glasses, such as fluorindates, which have the advantage of low losses, low phonon energy and the possibility of high dopant levels.

In addition to this activity, the design and construction of high-frequency antennas, in the band of millimeter and sub-terahertz waves, will allow to realize high-speed transmission systems (beyond 5G/6G). The design and construction of components at frequencies between 60 GHz and 300 GHz is a challenge that promises many advantages:

1) The miniaturization of the devices allows a very high degree of integration even with the same communication network but requiring high manufacturing precision. This need can be met by the use of high-precision laser prototyping equipment in addition to additive manufacturing techniques (3D printing);
2) the supply of sub-terahertz antennas requires electro-optical conversion, which can be overcome by adopting Microwave Photonics solutions;
3) the conventional planar technology project introduces losses, power limitations and low efficiencies, which can be remedied by appropriately designing antennas in Substrate Integrated Waveguide (SIW) technology with partially emptied substrate, reducing dielectric losses, increasing radiation efficiency and providing a low-cost solution compared to bulk metal antennas.

The aim of the research activity is to design some innovative optical devices (for example, to be identified between amplifiers, sensors, broadband sources and fiber optic lasers) and millimeter waves (such as antennas and filters), through the use of professional software (e.g. CST Microwave Studio, COMSOL Multiphysics, Ansys HFSS), with the intention of providing a proof of concept (PoC) of integration of the two families, in view of the wide range of applications IoT and 6G.

The activities can be summarized as follows:

1) State-of-the-art study of medium infrared optical devices based on innovative glass (I year);
2) State-of-the-art study of millimeter and sub-terahertz wave antennas (I year);
3) Design and optimization of the devices with professional software (II year);
4) Fabrication and experimental validation of the devices at the laboratories of the Department of Electrical and Information Engineering (DEI) and the Interdepartmental Center "Magna Grecia" of Taranto (II-III year).

Method of carrying out the research activity

The research activity can be supported by the skills already possessed by the MOE research group, coordinated by Prof. Francesco Prudenzano, by collaborations of italian and foreign universities, companies and research entities. In particular:

1) Politecnico di Milano (Prof. Gianluca Galzerano;);
2) Politecnico di Torino (Prof. Guido Perrone, Prof. Stefano Taccheo);
3) Université de Rennes 1 (Proff. J. Troles, V. Nazabal);
4) Institut d'Electronique et des Technologies di numéRique (IETR) (prof. Mauro Ettorre);
5) CNR-IFN gruppo CSMFO di Trento (Dr. Alessandro Chiasera);
6) ISL Institut franco-allemand de recherches de Saint-Louis (Dr. Stefano Bigotta)
7) Le Verre Fluoré (Dr. Solenn Cozic, Dr. Samuel Poulain)
8) University of Southampton (Dr. Christopher Holmes)

Additional partnerships may be added to these already established.

The construction of microwave and millimeter wave devices will take place at the DEI laboratories in Bari and the Interdepartmental Center "Magna Grecia" in Taranto, using laser prototyping equipment. In addition, to the construction, it will be possible the devices characterization, via the network analyzer (VNA) and the anechoic chamber. Optical devices, on the other hand, can be made using the Vytran splicer.

GRANT N.6
DRIEI

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

Topic: “Development of advanced monitoring strategies based on AI for collaborative robotics "

RESEARCH PROPOSAL

a) Research topic and coherence with the National Strategy of Intelligent Specialization (SNSI) approved by the European Commission

The goal of the PhD program is to study, develop and test advanced control strategies based on artificial intelligence for applications in collaborative robotics. In particular, the goal will be the design and prototype construction of a robotic system capable of reproducing precision movements, for example those that make up a particular type of tailored sewing.

The research theme complies with the SNSI since it takes place within the SNSI thematic area Intelligent and sustainable industry, energy and environment and in particular within the development trajectories "Innovative production processes with high efficiency and for industrial sustainability ". In fact, the research will use, for the development of control and diagnostic techniques, the strategies of artificial intelligence and deep reinforcement learning based on enabling technologies typical of Industry 4.0, such as cloud computation, simulation and optimization, just to name a few. .

Furthermore, the research is part of Cluster 4 of the Digital, Industry and Aerospace PNR pursuing the following objectives:

OB4: Consolidate and enhance reliable digital and emerging technologies.

OB7: Strengthening the industry-research ecosystem and technology transfer.

The resulting impacts will be:

IMP6: Definition of an inclusive society in the use of technologies for the individual and for the development of the economy.

IMP8: Improvement of industry-university relations and creation of a virtuous circle of skills transfer.

b) Proposed research activity, methodologies and contents

The project will study and implement artificial intelligence and deep reinforcement learning and machine learning technologies applied to collaborative robotics. For this purpose, simulation techniques will be used to evaluate and test the proposed procedures. At the end of the project, a collaborative robot prototype capable of performing precision movements will be built.

c) Degree of research innovation

The proposed project creates a high added value in scientific terms as it will develop artificial intelligence and deep reinforcement learning technologies that can be used in various industrial sectors. From a 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 digitalization of industrial processes in an Industry 4.0 perspective.

GRANT N. 7
DRIEI

M.D. 352/2022
Co-founded by: Martur Italy s.r.l.

Topic: "Development of AI applied to computer-aided engineering, the metaverse for car industry production processes and machine learning"

RESEARCH PROPOSAL

Artificial intelligence represents a great opportunity for manufacturing companies to reduce operating costs, improve productivity and create intelligent applications to support the production process. The European market seems to be a step forward on such a topic, and Italy is also gaining an emerging role thanks to the activities related to Industry 4.0 and Digital Transformation. This research proposal fits into this panorama.

The long-term objective of the candidate's work is to provide the company with an organizational and process structure capable of rapidly and continuously introducing new technologies to support the innovation in the manufacturing industry. The production, assembly and distribution systems have always produced enormous amount of data and today, thanks to intelligent systems for process and analysis, they can be effectively used, along the entire value chain and assuming an increasingly decisive role of guide in the company decision-making systems.

The proposal aims to integrate the new frontiers of artificial intelligence in the creation of optimization models for prediction purposes and employed in various research and development sectors of the company such as structural calculation, design, and technological processes improvement.

The candidate, with the support of the DRIEI PhD faculty board, will develop Artificial Intelligence applications within a transversal perspective, ranging from topics related to Business Intelligence for the improvement of company performances to research topics related to field of computational analysis (linked or not to the field of structural calculation).

Regarding the field of computational analysis, it is part of a broader process of business innovation which includes the modeling of all production processes and the characterization of the materials.

The interdisciplinarity and technical feasibility of the research proposal is supported by the availability of facilities and laboratories of the Polytechnic University of Bari in which the candidate will conduct experimental activities.

Such experimental activities are strongly linked to the proposal as the creation of the dataset is a process of fundamental importance in the creation of any artificial intelligence model. The proposed path will therefore include a first phase (6-8 months) dedicated to the study of the related scientific literature and the training of the candidate, a second phase (15-18 months) dedicated to the development and implementation of the innovative solutions proposed and a final phase of validation, testing and presentation of the results. The candidate's activities will develop in the context of the collaboration between MARTUR FOMPAK INTERNATIONAL, and the Polytechnic University of Bari already started with the research and development project "INNOVATIVE MECHANISMS FOR HIGH SAFETY AND COMFORT CAR SEATS" and with the

establishment of the public-private laboratory "Research and Development Center" located at the Japigia branch of the Polytechnic University of Bari.

GRANT N.8
DRIEI

M.D. 352/2022
Co-funded by: Esaote s.p.a.

Topic: "*New generation digital gradient amplifiers for MRI*"

RESEARCH PROPOSAL

a) Research theme and coherence with the National Strategy of Intelligent Specialization (SNSI) approved by the European Commission

The proposed research falls within the macro-theme of biomedical electronics. This issue is consistent with the technological lines outlined in the SNSI, as it is fully inserted in the national thematic area "Health, nutrition, quality of life", with specific reference to the national trajectory "E-health, advanced diagnostics, medical devices and mini invasiveness".

b) Proposed research activity, methodologies and contents

The project aims to develop a new concept of gradeinet apmlifier (GRA) for magnetic resonance equipment through the demonstration up to TRL5 of a board that is able to regulate with great accuracy the current d exit of the GRA. The board will include a Field Programmable Gate Array (FPGA), which will implement a Proportional-Integral-Derivative (PID) controller.

The results of this project can be implemented directly into the new magnetic resonance equipment that Esaote is developing.

c) Degree of innovation of the proposed research for the intervention sector

The GRA is one of the key electronic subsystems of an MRI equipment. Specifically, it is the power module that supplies the current to the gradient coils, located within the magnet cavity, responsible for generating the variable magnetic fields within the imaging volume of the equipment. The functional characteristics of the GRA significantly affect the performance of the equipment. Currently the GRA is very cumbersome and typically makes use of very complex analog regulators that employ numerous passive components. The ambitious goal of the project is the implementation of the regulator via FPGA, with consequent advantages in terms of size and reliability.

d) Coherence of the research topic with the disciplinary field of the PhD and with the composition of the Academic Board

The research topic is consistent with those of the Scientific Sector ING-INF / 01 "Electronics", since it includes aspects of digital, analog, and biomedical electronics. The research application scenario is related to advanced biomedical imaging equipment. For these reasons, the research proposal is consistent with the disciplinary framework of the Electrical and Information Engineering Doctorate. The teaching staff of the course includes professors of the Scientific Sector ING-INF / 01 with specific experience on the research topic.

e) Technical feasibility of the proposal and implementation timeline

The proposed research activity will be organized according to the following work packages (WPs).

WP1: Specifications and requirements (6 months).

WP2: HW implementation (18 months).

WP3: Firmware (12 months)

WP4: Performance verification (6 months).

f) Synergies with respect to the possible subsequent employment of the researchers

The proposed research activity will be carried out in close collaboration with the company. From the beginning of the course, the PhD student will carry out his / her activity in close contact with Esaote employees. Through this approach, the graduate student will gradually acquire the dynamics and the transversal skills typically required in the world of work.

The company is constantly recruiting young electronics engineers with good systems skills. This type of profile is extremely difficult to identify among recent graduates (electronic engineers), while the doctoral student who will conduct the proposed research will have, at the end of the three-year period, a profile of skills in line with what is required not only by Esaote but also by numerous others Italian and foreign companies operating in the same or similar markets.

GRANT N.9
DRIEI

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

Topic: "*Real-Time Ship Detection on satellite SAR data*"

RESEARCH PROPOSAL

a) Research theme and coherence with the National Intelligent Specialization Strategy (SNSI) approved by the European Commission

The proposed research falls within the macro-theme of HW / FW systems for data processing on board of satellite platforms. This theme is consistent with the technological lines outlined in the SNSI, as it is fully inserted in the national thematic area "Aerospace and Defense", with specific reference to the trajectory "Earth observation systems, in the field of missions, of tools and data processing ".

b) Proposed research activity, methodologies and contents

The project will aim to develop a HW / FW system based on FPGA for the real-time detection of ships to be used on board of Earth observation satellites equipped with Synthetic Aperture Radar (SAR) payloads. The results of this project can be implemented directly on board of satellites with SAR sensors that will be launched by MetaSensing in the next few years, or on other SAR satellites.

c) Degree of innovation of the research proposed for the sector of intervention

The innovative aspect of the project is the implementation of the algorithm on the latest generation RFSoC (Radio Frequency System-on-Chip) system (ie Zynq UltraScale + RFSoC) to allow the generation of information in orbit in real time and the reduction of the amount of data to be transferred to the ground for further processing. During the project, for the development of the algorithm, methods based on artificial intelligence will also be verified and used with Machine Learning and Deep Learning techniques applied to extensive training datasets generated by the innovative SAR simulator (KAISAR) developed internally and in use at MetaSensing. KAISAR is a realistic, physics-based simulator of SAR data for generating annotated training datasets to support the development of artificial intelligence algorithms. Thanks to the implementation on NVIDIA graphics card technology (GPU-CUDA), the KAISAR is able to generate realistic SAR images from 3D models of different scenarios and objects in a few seconds for each scene.

d) Consistency of the research topic with the disciplinary field of the PhD and with the composition of the Academic Board

The research topic is consistent with those of the Disciplinary Sector ING-INF / 01 "Electronics", since it includes aspects of digital electronics and programmable logic devices . The application scenario of the research is broad and includes, among other things, radar systems to be used on board satellites and constellations of satellites, reconnaissance aircraft, unmanned aircraft. For these reasons, the research proposal is consistent with the disciplinary framework of the Electrical and Information Engineering PhD Program. The teaching staff of the course includes professors of the Disciplinary Sector ING-INF / 01 with specific experience on the research topic.

And) Technical feasibility of the proposal and implementation time schedule

The proposed research activity will be organized according to the following work packages (WPs).

WP1: Specifications and requirements (6 months).

WP2: HW implementation (12 months).

WP3: Firmware (12 months)

WP4: Performance verification (12 months).

f) Synergies with respect to the possible subsequent employment of the researcher (in relation to the world of work).

The proposed research activity will be carried out in close collaboration with the company. From the beginning of the study, the PhD student will carry out his / her activity in close contact with Metasensing employees. Through this approach, the graduate student will gradually acquire the dynamics and the transversal skills typically required in the world of work.

Metasensing is constantly recruiting young electronics engineers with good systems skills. This type of profile is extremely difficult to identify among recent graduates (electronic engineers), while the doctoral student who will conduct the proposed research will have, at the end of the three-year period, skills compliant to those ones required not only by Metasensing but also by numerous others Italian and foreign companies operating in the same market.

GRANT N.10
DRIEI

M.D. 352/2022
Co-funded by: Northrop Grumman Italia s.p.a.

Topic: "*An interferometric optic fibre gyroscope for cost-sensitive applications*"

RESEARCH PROPOSAL

a) Research theme and coherence with the National Intelligent Specialization Strategy (SNSI) approved by the European Commission

The proposed research falls within the macro-theme of fiber optic sensors for inertial navigation systems. This issue is consistent with the technological lines outlined in the SNSI, as it is fully part of two of the five national thematic areas, those called "Digital Agenda, Smart Communities, Intelligent Mobility Systems" and "Aerospace and Defense", with specific reference to the trajectories "Intelligent urban mobility systems for logistics and people", "UAV (Unmanned aerial vehicle) for civil use and ULM (ultra-Léger Motorisé)", "Space robotics, for service operations in orbit and for exploration missions ".

b) Proposed research activity, methodologies and contents

The proposed research aims to develop an interferometric tactical grade gyroscope whose sensing element is a polarization maintaining optical fiber coil. Such sensors are already available on the market but have a cost that make them incompatible with so-called cost-sensitive applications, such as robotics, autonomous carls, unmanned aircraft. The aim is to identify technical solutions related to the boradband optical source, the modulation techniques, and to the readout electronics that reduce cost without sacrificing performance.

c) Degree of innovation of the proposed research for the sector of intervention

The proposal aims to develop a highly innovative sensor, based on commercially available components, which supports the inertial navigation of different classes of self-driving vehicles / aircraft and which has costs compatible with this application scenario. These vehicles / aircraft currently use MEMS components, whose resistance to thermo-mechanical disturbances is limited by the fact that they include moving parts. The sensor that will be developed will be completely free of moving parts and will have performance and cost compliant with the requirements of the target applications.

d) Coherence of the research topic with the disciplinary field of the PhD and with the composition of the Academic board

The research topic is coherent with those of the Scientific Sector ING-INF / 01 "Electronics", since it includes aspects of microelectronics, electronics of sensors, digital electronics, optoelectronics and photonic devices. The application scenario of the research is broad and includes, among other things, self-driving vehicles / aircraft and robotics. For these reasons, the research proposal is consistent with the disciplinary framework of the Electrical and Information Engineering PhD Promagm. The teaching staff of the course includes profesors of the Scientific Sector ING-INF / 01 with a specific experience on the research topic.

e) Technical feasibility of the proposal and implementation schedule

The research activity proposed will be organized according to the following work packages (WPs).

WP1: Specifications and requirements (6 months).

WP2: HW implementation (18 months).

WP3: Firmware (6 months)

WP4: Performance verification (6 months).

f) Synergies with respect to the possible subsequent employment of the researcher (in relation to the world of work).

The proposed research activity will be carried out in close synergy with the company involved. The graduate student will work closely with Northrop Grumman staff from the start of his/ her research activity. In this way, the graduate student will progressively learn the dynamics of company work and those transversal skills (soft skills) that are essential for subsequent insertion into a company.

Northrop Grumman Italia constantly hires young engineers with a solid basic background in the field of electronics, photonics, and microsystems technology, complemented by adequate skills in the systems field. Such profiles are very difficult to identify among new graduates (electronic or automation engineers) while the graduate student who will carry out the proposed research will have, at the end of the three-year course, a professional profile compatible to that one required by Northrop Grumman and other Italian and foreign companies operating in the same market.

GRANT N.11
DRIEI

M.D. 352/2022
Co-funded by: NPC New Production Concept s.r.l.

Theme: " Development of a high-performance On-Board Computer for nanosatellite platforms"

RESEARCH PROPOSAL

a) Research topic and coherence with the National Strategy of Intelligent Specialization (SNSI) approved by the European Commission

The proposed research falls within the macro-theme of digital systems for data processing, with specific reference to the application field of space. This theme is consistent with the technological lines outlined in the SNSI, as it is fully inserted in the national thematic area "Aerospace and Defense", with specific reference to the trajectory "Earth observation systems, in the field of missions, tools and data processing ".

b) Proposed research activity, methodologies and contents

The project will aim to develop an on-board computer based on a flash FPGA to be integrated into satellite platforms with a mass of less than 20 kg. The developed computer should have a low power consumption (<1 W) and a form factor less than 15cm x 15cm. The results of this project can be implemented directly on board of earth observation satellites that will be launched by NPC Spacemind in the next few years, or on other satellites that are currently under development.

c) Degree of innovation of the research proposed for the intervention sector

One of the main challenges in the field of developing new satellite platforms is on-board processing. Space computers must ensure high performance and reliability using limited resources (power, size, weight and cost), in an extremely difficult environment (due to radiation, temperature, vacuum and vibrations). As the size of satellite platforms decreases, the technological challenges for on-board processing become particularly complex. This proposal aims to address these challenges by demonstrating an on-board computer whose main innovation lies in the use of a flash FPG. FPGAs based on glash memory offer the advantage of low power consumption and are more fault tolerant due to their inherent robustness against single event induced noise than FPGAs based on SRAM.

d) Coherence of the research topic with the disciplinary area of the PhD and with the composition of the Academic board

The research topic is coherent with those of the Scientific Sector ING-INF / 01 "Electronics", since it includes aspects of digital electronics and programmable logic devices. The research application scenario is broad and includes, among other things, processing systems for satellite platforms. For these reasons, the research proposal is consistent with the disciplinary framework of the Electrical and Information Engineering PhD Progam. The teaching staff of the course includes professor of the Scientific Sector ING-INF / 01 with specific experience on the research topic.

e) Technical feasibility of the proposal and implementation schedule

The research activity proposed will be organized according to the following work packages (WPs).

WP1: Specifications and requirements (6 months).

WP2: HW implementation (18 months).

WP3: Firmware (12 months)

WP4: Performance verification (6 months).

f) Synergies with respect to the possible subsequent employment of research doctors (in relation to the world of work).

The proposed research activity will be conducted in close collaboration with the company. From the beginning of the study, the PhD student will carry out his / her activity in synergy with the employees of the partner company. Through this approach, the graduate student will gradually acquire the dynamics and the soft skills typically required in the world of work.

NPC Spacemind constantly recruits young electronic and aerospace engineers with good skills in the field of systems. This type of profile is extremely difficult to identify among recent graduates, while the doctoral student who will conduct the proposed research will, at the end of the three-year period, have skills compliant with that one is required not only by the partner company but also by numerous other Italian and foreign companies operating in the same market.

GRANT N.12
DRIEI

M.D. 352/2022
Co-founded by: Tesmec Rail s.r.l.

Topic: "Reliable, smart and green propulsion control of construction and maintenance railway vehicles"

RESEARCH PROPOSAL

The proposal focuses on the innovation of railway vehicles used for the construction and maintenance of railway lines. Tesmec Rail is a Tesmec Group company operating in the design, testing and production of railway vehicles for the installation and maintenance of the catenary. It also provides diagnostic solutions for the railway infrastructure, with the aim of developing integrated solutions in the railway sector. The plant was also built through the Investment and Development Programs of the Puglia Region, with the aim of creating a research center for high-tech projects in the railway sector.

Most of the vehicles produced by the companies in such sector are characterized by a diesel or hydraulic propulsion assisted by a thermal engine. This solution is clearly in contrast with the green propulsion needs. In addition, the electrification of such vehicles is difficult as they operate on construction sites not yet equipped with an overhead electricity distribution line. Therefore, the development of innovative propulsion architectures requires considerable efforts within the scientific and disciplinary sectors of automation and electric drives, in full compliance with the skills of the DRIEI PhD faculty board. The proposal is in line with the following development trajectories envisaged by the National Strategy of Intelligent Specialization: "Innovative production processes with high efficiency and for industrial sustainability", "Embedded electronic systems, smart sensor networks, internet of things", "Reduction of the environmental impact (green engine)".

The proposal focuses on the development of innovative control architectures for the green hybrid electrical-hydraulic propulsion on maintenance and construction railway vehicles. The electrification of these vehicles aims to efficiently and reliably coordinate the electric traction obtained through different energy sources: catenary at different voltage levels, generator, battery pack connected to an electric motor and hydraulic propulsion. Considerable importance will be given to the development of algorithms for the energy regeneration of the battery pack also when the propulsion is hydraulic, developing an innovative solution not yet fully investigated in the current state of the art. The main task will be aimed at minimizing the energy waste and emissions without losing performances. Particular attention will be paid to the reliability of the components, also developing innovative predictive diagnostic solutions based on data collected from various systems.

In the first phase, the PhD student will develop detailed mathematical models for describing the vehicle, its traction and driving dynamics. These models will be developed in a first phase in the MATLAB / Simulink environment. Subsequently, with the aid of the Hardware-In-the-Loop methodology, these models will be validated using data recorded on already operating vehicles. Appropriate control strategies for the correct distribution of the traction demand among the various propulsive components will be implemented and validated on these models. In this phase, state-of-the-art control algorithms will be developed and aimed at maximizing the safety and integrity of the vehicle, for example by considering anti-skid controllers. Moreover,

the developed models will provide the basis for integrating "digital twins" of vehicles for predictive diagnostics carried out also with the aid of Artificial Intelligence techniques. The development activities will be supported by appropriate experimental tests on operating vehicles.

Tesmec Rail is strongly motivated to invest in human resources for the development of research activities in order to offer cutting-edge technological products. As part of its collaborations with the Polytechnic University of Bari, the company has already activated a close collaboration since 2020 focused on the research in the railway sector. To date, several undergraduates have been regularly hired.

GRANT N.13
DRIEI

M.D. 352/2022
Co-founded by: Arol s.p.a.

Topic: “AI and intelligent control for innovative closure and capping systems in the food and beverage industry”

RESEARCH PROPOSAL

The proposal focuses on innovating the automation sector of packaging production plants for the "food and beverage" industry. The AROL company is one of the world players in producing highly automated machines for closing wrappers (bottles, jars, bags) employed in various sectors of the Italian and international food chain.

At present, the design of such machines poses several scientific challenges, such as preserving product quality, reducing waste, increase efficiency in terms of energy consumption, production times and costs. Those challenges are handled using technologies of multiple nature, which largely fall within the scientific disciplinary sector of automation. The proposal is fully in line with 2 of the 32 technological development trajectories with national priority, specifically: "Smart and sustainable industry, energy and environment: Innovative highly efficient production processes for industrial sustainability", and "Health, nutrition, quality of life: Systems and technologies for packaging, conservation and traceability and safety of food production".

The aim of the proposal, in full coherence with the skills of the DRIEI PhD faculty board, is the development of intelligent capping machines using new generation sensors and actuators to obtain closure processes with greater guarantees in terms of product quality while lowering costs and energy consumption. The topic, intrinsically multidisciplinary, involves the improvement of the closing/capping operation through more sensorized robots which are capable of monitor the main elements (environmental factors, characteristics of the casing and cap, handling and sealing characteristics) that influence the quality of the closure while the operations are in progress, reducing the need for destructive a-posteriori checks.

The PhD candidate will carry out mathematical modeling studies, design of sensor systems and innovative control algorithms based on the state of the art of hw/sw technologies and modern techniques of "Data model identification" and "Intelligent control".

During the studies, the intelligent machine will be modeled as a complex hybrid process with partially continuous and partially event-based dynamics. The model and the control strategies of the machine will be implemented in modern advanced programming and simulation environments (e.g., Matlab / Simulink) and suitable for rapid prototyping of decision and control algorithms based also on Reinforcement Learning and Artificial Intelligence, providing a consistent innovation both in the hardware and software. The research activities in this area are the basis of a partnership agreement between AROL Spa and Polytechnic of Bari which led to the creation of the public-private laboratory "Cyber-physical Systems", where the activities of the candidate student will be carried out. To date, most of the research fellows, postdocs and doctoral students who worked in the laboratory have been hired with a permanent contract by the AROL company.