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XXXV Cycle

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Editor-in-Chief: Giuseppe Sergioli

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UniCa PhD Book – XXXV Cycle
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INDEX

Introduction of the Rector and Vice-rector

We are very honored to write the introduction to this book. The concept of the volume stemmed from the close attention the University of Cagliari reserves on post-graduation courses and on PhD courses. Allowing the worthiest graduates to access highly professional PhD courses, is of crucial importance, not only for the future of our University, but especially to achieve an elevated specialization to be spent in the world of research and in the regional, national and international workforce. In recent years, the policy of our University has greatly enhanced its focus on the internationalization of our courses, and it is highly rewarding for us that many European academies have started to share our cultural proposal of advanced education.

Our University has many talented students who deserve to be inspired and encouraged to nurture and enhance their potential. Additionally, it has all the requirements to be attractive to students from other universities. We must be grateful to the professors and researchers of our academy for working hard to maintain the high level of our PhD courses, and for supporting our PhD students. The same gratitude should be deserved to the administration, in particular the Direzione Didattica, for ensuring the appropriate working framework to students and academics.The volume summarizes the interesting and stimulating research led by our PhD students, showing the excellent level of their skills and expertise. Of course, the ultimate scope of this volume is to support the growth and development of the Sardinian society thanks to the participation and work of our PhD students.

Francesco Mola, Rector
Gianni Fenu, Vice-Rector

PhD programme in Chemical Science and Technology

Coordinator: Carla Cannas
Vice-coordinator: Sebastiano Garroni

The PhD in Chemical Sciences and Technologies, since 2013 (XXIX cycle), is the only PhD in Chemical Sciences in Sardinia and involves the universities of Cagliari (UNICA) and Sassari (UNISS) with a joint agreement and five Departments. The aim of the course is training highly qualified scientists by giving the opportunity to young italian and foreign master-degree level candidates to plan and carry out a research project in the most advanced topics in the field of chemical sciences and technologies. With this goal the PhD Board offers a tailored teaching path accompanied by the possibility to directly interact with institutions, industries, and scientists active in the national and international *scenario* though a research period in international laboratories. The active participation to conferences, workshops, advanced schools and national and international meeting as well as tutoring activities are strongly recommended. The XXXV cycle consists of 9 PhD students (3 grants funded by UNICA, 4 by UNISS and 2 more by MUR within PON-RI Program), the majority having applied for the additional label of Doctor Europaeus. During the previous four cycles other foreign students coming from India, China, Hungary and South Africa have been hosted and several co-joint agreements were activated with various universities like Cordoba, La Roja, Angers, Barcelona and Va-

lencia. The high level of the research activities has been recognized at national and international level through several distinctions: in the last four cycles four PhD students have been awarded as the best PhD thesis by the Italian Chemistry Society (SCI) and further awards have been received as best presentations or best posters. Furthermore the successful participation to DAAD Program has been acknowledged for two scholarships.

Role of thin films on functional materials

Deborah Biggio

Deborah Biggio is PhD student in analytical chemistry and surface science, under the supervision of Prof. M. Fantauzzi and Prof. A. Rossi, at the University of Cagliari. She graduated in M.Sc. Chemical Science (*cum laude*, July 2019). She had worked as scientific assistant at the Department of Materials of the ETH Zurich (CH) at the Surface Science and Technology laboratory under the supervision of Prof. N. Spencer. During this experience, she was introduced to tribology, which she deepened during the following months as visiting PhD student at the same department.

PhD project title is*"Growth, characterization, and functional properties of thin films on metallic and ceramic substrates"*. The work is focused on the study of the functional properties of thin films on materials, such as the corrosion resistance, the wear resistance and the friction reduction, that depend both on bulk properties (elasticity, tensile strength, density, hardness, electrical and thermal conductivity) and on the morphology, the composition and the structure of the thin films formed following the contact of the material with the environment in which it is normally used. The aim of her project is to develop an analytical method for characterizing thin films formed on metallic substrates such as brass alloys for musical wind-instruments after the contact with different artificial saliva formulations and on ceramics substrates (Si_3N_4) after the sliding tests with different lubricants such as room-temperature ionic liquid (IL) and a blend of IL plus an additive. The composition and the

elemental distribution of the chemical species in the films can be determined *ex- situ* by surface sensitive techniques, and they are correlated with properties such as corrosion resistance, anti-wear, and lubrication measured by *in-situ* techniques, e.g. electrochemical and tribological tests. As far as copper-zinc alloys (brass), the formation of corrosion products (patina) due to the contact with saliva can play an important role for the stability of these alloys. When a brass wind instrument is played during a performance, the contact with saliva might result in the formation of a patina that can affect the acoustic properties of the instrument itself. Last but not least, the wind instrument might be corroded over time and this is an undesired effect especially in the case of historically informed performances. Since human saliva composition is complex, strongly variable and depends on environmental, physiological and pathological factors, artificial saliva is used for corrosion studies, assuming that the chemical composition is similar to the natural one. Several formulations of artificial saliva have been proposed for electrochemical studies on alloys used in orthodontics, but they typically consist of solutions of inorganic salts, mainly chlorides, phosphates and thiocyanates. In this project, the presence and the role of organic compounds in artificial saliva formulations is investigated. The results suggest that thickness and composition of the surface films are influenced by saliva formulation and by the exposure time as well as their corrosion resistance. Some constituents of the model saliva solutions are found to favour zinc dissolution resulting in a surface with different colour, composition and sound.

D. Biggio, et al. The role of organic compounds in artificial saliva for corrosion studies: Evidence from X-ray photoelectron spectroscopy. Surf Interface Anal., 2022; 1- 7.

Development of processes and materials for the photoconversion and separation of CO_2

Luca Cappai

Luca Cappai received his bachelor's degree in Chemistry in 2016 and his master's degree in Chemical Sciences in 2019 at the University of Cagliari. In 2019 he started his PhD in Chemical Sciences and Technologies at the University of Sassari with the project *"Development of Innovative processes and materials for the photoconversion and separation of CO_2 from mixtures of combustion products"* under the tutorship of prof. Gabriele Mulas. The PhD project funded by Programma Operativo Nazionale Ricerca e Innovazione 2014/2022 (PON-RI) was also part of CO_2MPRISE project, a MSCA project funded within the Horizon2022 scheme. Luca completed his international and industrial experience spending, during his PhD studentship, 6 months in Sotacarbo ScpA structures in Carbonia (Italy), 4 months in Monolithos Catalysts Ltd. facilities in Athens (Greece) and 2 months in the laboratories of the University of Chile in Santiago (Chile). The ever-increasing Carbon Dioxide concentration in the atmosphere is recognised as the main responsible of green-house effects, causing climate changes and related environmental troubles. It is giving rise to the need of elaborating new strategies and technologies to mitigate the effects of CO_2 increased emissions. Within the so-called Carbon Capture Utilization and Storage strategies (CCUS), the PhD research activity has been focused to develop and test feasible strategies to convert CO_2 into valuable products, activating the conversion process via solar irradiation on waste and low-cost silicate-based materials. Mineral Olivine, defined as a solid

solution fayalite (Fe_2SiO_4) and forsterite (Mg_2SiO_4), was investigated as a suitable candidate for CO_2 conversion for its basicity. Unfortunately, such mineral is not able to efficiently absorb solar irradiation in the visible wavelength range, then Olivine was modified to achieve a suitable energy band gap, proper to visible light absorption. This, in turn, is the requisite to potentially promote CO_2 reaction on the material surface. Titania was added to Olivine through mechanical ball milling process and via impregnation method. Photochemical conversion tests were carried out, in presence of H_2O, by suitably prepared reactors, using either batch conditions or continuous flow of CO_2. Reaction tests were performed under properly arranged experimental set-up. Several experimental techniques were employed to evaluate CO_2 conversion and to analyse the solid samples and gaseous reagent and products. CO_2 conversion was observed to depend on the solid phase stoichiometry and its preparation route. GC analyses of the gas phases showed that part of CO_2 was reduced to light hydrocarbons, mainly methane, while XRD and SEM/EDS measurements highlighted the occurrence of mineral carbonation on the solid surface. Furthermore, the photochemical reactivity of different silicate-based compounds, arising from industrial waste materials has been studied. Preliminary tests evidenced high rates of CO_2 conversion into metal carbonates already after 2 h of solar irradiation. Finally, in view of circular CO_2 reutilization, the carbonate products were studied as component of dual-phase carbonate membranes for CO_2 separation from flue gases.

Taras A. et al., Procedimento per la conversione della anidride carbonica in composti chimici ad alto valore aggiunto mediante un processo meccanochimico in condizioni di flusso di gas in modalità continua, USS005PCT, International Searching Authority, 27/05/2021.

Computer modeling and simulation techniques for gas sweetening

Paola Carta

Paola Carta is spending her PhD under the supervision of Prof. M.A. Scorciapino at University of Cagliari, in the group of Applied Spectroscopy and Molecular Modeling of the Dept. of Chemical and Geological Sciences. She got her M.Sc. in Chemical Science in 2019, presenting a thesis on the structural characterization of bioactive peptides with a combination of experimental and computational techniques. During the PhD, she focused on the computational techniques, namely, Gran Canonical Monte Carlo and Molecular Dynamics simulations. She had the chance of spending 6 months at the University of Antwerp, where, under the supervision of Prof. E. Neyts, she approached the REAXFF simulations and DFT calculations.

The title of the PhD. project is "*Study of silica-based ordered mesoporous sorbents for gas sweetening by concatenated computer simulation techniques*" and aims at shedding light on the microscopic aspects of gas adsorption on a particular class of silica. These materials have a high surface area, uniform pore size, and can be differently functionalized. MCM-41 and SBA-15 are the two most widely employed silica sorbents in many fields.

The research is focused on CO_2, which is the main responsible of the well-known greenhouse effect. The removal of CO_2 from gas stream, either natural or synthetic, is essential. The capture (and reuse) of CO_2 at the point of emission represents one of the most important global challenges. Also, remotion from fuel gas is important, since its acid-

ity determines pipeline corrosion and expensive plant maintenance. Computational techniques allow to simulate and follow in 3D the gas adsorption on the surface of the sorbent materials. It is possible to analyze the different parameters that affects the capacity and selectivity of the materials, unveiling the microscopic and energetic details of the gas interaction with the solid surface. Performance can be predicted, and guidelines for the preparation of optimized sorbents can be provided. During the project, atomistic models of MCM-41 and SBA-15 have been prepared to match all the geometrical parameters of the real samples. The adsorption of pure CO_2, pure CH_4, and their mixtures has been investigated inside these materials, with different pore size and at different pressure. Primary amines, which are reported to increase CO_2 capacity and selectivity, have been added to functionalize the silica surface, and the investigation of adsorption has been performed by varying the pore size and the pressure. DFT calculations have been also performed to investigate the thermodynamics of the reaction between the CO_2 and the amine groups.

The main goal has always been the connection between the macroscopic performance and the microscopic details of the interactions between the gas molecules and the material surface groups. When compared to the literature, the work performed during the PhD has represented several innovations. The computer models of the materials have been largely improved, by including most the fundamental details revealed by experiments on real samples (see the ref.). Beyond the pore radius, the role played by surface density of the functional groups has been emphasized. In addition, the thermodynamic heterogeneity of bare silica surface, for the first time as far as we are aware, has been taken into explicit consideration.

Carta P. et al. Experiments-Guided Modeling of MCM-41: Impact of Pore Symmetry on Gas Adsorption. Adv. Materials Interf., 2022; 9: 2201591.

Advanced Rose Bengal Delivery Systems for Local and Systemic Management of Cancer

Sara Demartis

Sara Demartis graduated with M.Sc. Pharmacy in April 2019, and she participated in the *post lauream* Erasmus+ Traineeship Program in the Faculty of Pharmacy of Valencia, Dept. of Pharmacy y Pharmaceutical technology and Parassitology, where she was introduced to scientific research. Indeed, after this experience, she enrolled in the Chemical Sciences and Technologies PhD program, focusing on Pharmaceutical Technologies for cancer therapy. She carried on her research activities mainly in the Dept. of Chemical, Physical, Mathematical and Natural Sciences of the University of Sassari under Prof. Elisabetta Gavini. During her PhD, she collaborated with the laboratory of Prof. Ryan Donnelly (School of Pharmacy, Queen's University Belfast) and Prof. Juergen Siepmann (Faculty of Pharmacy, University of Lille), where she spent nine and three months, respectively. The research activity of her PhD was focused on developing advanced Rose Bengal delivery systems applied to cancer therapy. Rose Bengal is a hydrosoluble molecule with high anticancer properties towards different cancer forms, including melanoma, breast, ovarian, gastric and colon cancers. However, Rose Bengal must be formulated in suitable delivery systems to maximise its therapeutic potential. The PhD thesis of Sara Demartis entitled "*Advanced Rose Bengal Delivery System for Local and Systemic management of Cancer*". It results from the development and characterisation of different Rose Bengal delivery systems. Melanoma is the most studied among the cancer cells sensitive to Rose Bengal. Indeed, Rose

Bengal has been shown to kill other melanoma cell lines at relatively low concentrations selectively. Melanoma is cancer that initiates in the most superficial skin layers and, if not treated, spreads to the dermis to further metastasise in several body organs. However, the potential of Rose Bengal to treat melanoma is limited by its poor biopharmaceutical profile. For this purpose, Sara Demartis developed flexible lipid nanocarriers loading Rose Bengal to be applied to the skin surface and attack superficial melanoma lesions. The current nanocarriers proved to increase the Rose Bengal toxicity towards melanoma cells and its delivery to the targeted lesions. However, to properly provide Rose Bengal delivery into the dermal layer and, consequently, to kill melanoma cells located in deeper skin strata, she developed a third-generation patch loading Rose Bengal nanocarriers in the laboratory of Prof. Ryan Donnelly. The patch is a polymeric microneedles system that painlessly pierces the skin, reaching the dermis layer; in this stratum, the polymeric microneedles dissolve thanks to the high-water content presence, releasing the nanocarriers. The efficacy of the patches has been demonstrated, and the investigation has been published in the Internation Journal of Pharmaceutics, with the title of "Trilayer dissolving polymeric microneedle array loading Rose Bengal transfersomes as a novel adjuvant in early-stage cutaneous melanoma management". Further, Sara Demartis was introduced to the field of 3D printing by Dr Eneko Larraneta (School of Pharmacy, Queen's University Belfast). Through the 3D-printing technique, she developed implantable devices loading Rose Bengal for local cancer management. The implants are in the millimetric range of size. They have been projected to be implanted close to the cancer lesion to provide a long-term Rose Bengal release while minimising systemic exposure.

Demartis S, Anjani Q, Volpe-Zanutto F, et al. Trilayer dissolving polymeric microneedle array loading Rose Bengal transfersomes as a novel adjuvant in early-stage cutaneous melanoma management. Int. J. Pharm., 2022; 627 122217.

Drug delivery systems for paediatric therapeutic needs

Noelia Nieto González

Noelia Nieto González was born in Plasencia (Spain) in 1995. She obtained her Master's Degree in Pharmacy at the University of Alcalá de Henares (Madrid, Spain) in 2019. In the same year, she started the PhD program in Chemical Sciences and Technologies (UniSS/UniCa School, XXXV cycle). As a PhD Student, she conducted her research at the Laboratory of Pharmaceutical Technology of the University of Sassari, under the supervision of Prof. Giovanna Rassu. She spent a 9-month research period abroad at the University College of London (UCL) in London, conducting a project funded by UCL and EuPFI (European Paediatric Formulation Initiative). He participated in 15 national and international conferences and congresses, and part of her doctoral project was published in two scientific articles. Her research project entitled *Research and development of drug delivery systems for paediatric therapeutic needs* is focused on developing new formulations for treating paediatric diseases. The Paediatric Committee of the *European Medicines Agency* (EMA) encourages research into medicinal products for children because numerous drugs are currently unavailable in formulations suitable for paediatric patients. The *United States Pediatric Formulation Initiative* suggested applying new technologies to paediatric drug formulations, for instance, nanotechnology. She recently published an article concerning the development of polymeric nanoparticles based on chitosan and cellulose acetate phthalate, without the use of surfactant, containing captopril to treat hypertension since a

formulation of captopril is required in this therapeutic area. As a result, chitosan/cellulose nanoparticles could be considered a suitable platform for captopril delivery in paediatrics for preparing solid/liquid dosage forms. She studies other drug delivery systems to treat rare diseases like multiple sclerosis. On the other hand, her research at UCL was focused on the administration of different paediatric formulations through enteral feeding tubes (EFTs). Nowadays, oral medicinal products are regularly administered to paediatric patients via enteral feeding tubes due to the rising prevalence of children living with severe illness or disability that results in reduced swallowing capacity and limited gastrointestinal access. Pharmacotherapy problems related to drug bioavailability, effectiveness, and safety are often associated with the inappropriate use of feeding tubes and administration techniques. The aim was to demonstrate the feasibility of administering medicinal products to paediatric patients through EFTs to improve drug product development in collaboration with pharmaceutical companies.

Nieto González N. *et al.* Surfactant-Free Chitosan/Cellulose Acetate Phthalate Nanoparticles: An Attempt to Solve the Needs of Captopril, Administration in Paediatrics. Pharmaceuticals, 2022, 15, 662.

New Synthesis Methods of Enzymes-MOFs Composite Materials for Biomedical Applications

Giada Mannias

Giada Mannias graduated, with full marks and laude, in Pharmaceutical Chemistry and Technology in July 2019, at the University of Cagliari (UNICA), presenting her Master Thesis "*New Synthesis Method for the Development of a Au-SiO_2 based Macro-Mesoporous Material for Tissue Regeneration*". In November 2019, she started her *Philosophiae Doctor* (PhD) Thesis, titled "*Development of New Synthesis Methods of Proteins/Enzymes-Metal Organic Frameworks (MOFs) Hybrid Composite Materials for Biomedical Applications*", at the Department of Chemical and Geological Sciences (UNICA), under the supervision of Prof. Guido Ennas. She spent six months at the University of Limerick in the group of Dr. Sarah Hudson from November 2021 to May 2022. Her PhD research dealt with the development of new synthesis protocols for the preparation of proteins/enzymes-Metal Organic Frameworks (MOFs) hybrid composite materials for biomedical applications. MOFs are a subclass of coordination polymers, consisting of metal centers, joined together by organic ligands to constitute highly porous architectures. Among MOFs, she focused on structures built on Fe^{3+} and 1,3,5-benzenetricarboxylate (BTC), also called Fe-BTC materials. Indeed, such materials are interesting candidates to be applied in numerous fields, including catalysis, gas storage and separation, sensing, drug delivery, and protein immobilization. This is due to their high porosity, stability in water, air and organic solvents, low costs, redox properties, and lack

of *in vivo* toxicity. However, traditional Fe-BTC synthesis via solvo/hydrothermal methods uses large amounts of solvents, are time-consuming, expensive, and requires high temperature and pressure and acidic conditions. Such harsh synthesis conditions could limit the use of these materials, especially for biomedical purposes. During her PhD, Giada focused on the development of innovative synthesis protocols to prepare Fe-BTC material under green, mild, and biocompatible conditions feasible for the *in situ* immobilization of biomolecules. In particular, she developed two different synthesis protocols, one via Mechanochemical approach, the other through Sonochemistry, under mild pH conditions, room temperature and short reaction times. Mechanosynthesis uses the energy generated by the impact with balls inside a mill. On the other hand, sonochemistry uses the energy generated by the implosion of bubbles due to the irradiation of the reaction solution with ultrasounds (acoustic cavitation). Both methods are cost efficient and faster than the traditional ones, being very promising to synthesize MOFs and opening up novel perspectives for their use in biomedicine. She investigated the influence of working pH conditions on the materials, revealing that neither microstructure nor thermal stability are affected by pH. Conversely, textural properties have proven to be tuned by simply varying the amount of base. She successfully employed these two synthesis protocols and tailored synthesis conditions for the immobilization of Glucose Oxidase (GOx) on Fe-BTC via *in situ* approach. She developed a facile and sensitive colorimetric biosensing assay for glucose detection, based on the use of these enzyme-MOF hybrid composite biocatalysts. Such approaches can be potentially adapted to an infinite variety of MOFs and biomolecules, making the fabrication of biomolecule-MOF-based composites a green, rapid, biocompatible, and usual procedure.

Mannias G. et al., Tailoring MOFs to biomedical applications: a chimera or a concrete reality? The case study of Fe-BTC by bio-friendly Mechanosynthesis. Comments Inorg. Chem., 2022. In press. https://doi.org/10.1080/02603594.2022.2153837.

Transition Metal Ions and their interactions with Proteins

Alessio Pelucelli

Alessio Pelucelli graduated in Pharmaceutical Chemistry and Technology in 2016, with distinction, presenting a thesis entitled 'Interaction of Ni(II) with peptide models of the TLR4 protein implicated in Nickel-induced allergic dermatitis'. The thesis was carried out under the supervision of Prof. Maria Antonietta Zoroddu and following an Erasmus experience at the University of Wroclaw (Poland), from which a collaboration with the research group of Prof. Elzbieta Gumienna-Kontecka was established. After graduation he spent a three-year period as a volunteer researcher in the field of NMR spectroscopy at the University of Sassari, where he then began his PhD in 2019 with a project entitled "Study and characterisation of peptide fragments involved in the formation of metal-protein complexes responsible in the pathophysiology of PCD (Protein Conformational Disorders)".

His research work, carried out under the supervision of Prof. Serenella Medici, focused on the importance of metal ions (particularly transition metal ions) in the human body, and how these agents can positively or negatively influence the rearrangement of specific proteins involved in the development of pathologies. Metal ions are physiologically present in human cells, where homeostatic mechanisms precisely regulate their quality and quantity. Some of them play a number of roles that are essential for survival, and either their deficiency or excess can cause poor health; others, on the other hand, are not part of human metabolism and can cause damage even if present in minute

quantities. These mechanisms are seriously challenged by the fact that food, water and the environment are also rich in metal ions that can be easily absorbed by humans causing health problems, particularly by interfering with proteins and enzymes that are the most plastic and easily influenced elements within cells. Through the NMR investigation of selected protein fragments, and by combining potentiometric studies, UV-Visible and EPR spectroscopies, and Circular Dicroism, it was possible to examine the coordination compounds that metal ions can potentially form under physiological conditions. The metal ions examined during this research work were predominantly Cu(II), Zn(II), Mn(II) and Cd(II), while peptide fragments were extracted from the hACE2 receptor and the FeoB operon. The latter was chosen and analysed in collaboration with the University of Wroclaw, where Alessio spent six months of his research period learning potentiometric techniques and applying them to his research work. The study of the FeoB operon has also allowed to expand the field of research to the interactions of metal ions (in particular Fe(II)) with bacterial proteins, laying the foundations for research aimed at a deeper understanding of these mechanisms with the purpose of paving new pathways in the interference with bacterial metabolism.

Peana M. et al. Metal Toxicity and Speciation: A Review. Curr. Medic. Chem., 2021; 28(35): 7190-7208.

Mechanochemically and thermally induced CO_2 transformation in presence of silicate-based raw materials and H_2O

Alessandro Taras

Alessandro Taras was born in Sassari in 1988. He attained a bachelor's degree cum laude in Chemistry and in 2017 he obtained a master's degree cum laude in Chemical Sciences at the University of Sassari. In January 2018, he got a post-graduate scholarship lasting 20 months at the University of Sassari, concerning the study of novel photocatalysts for the conversion of carbon dioxide to methane. Between 2018 and 2022, he participated in the European project MSCA CO2M-PRISE coordinated by the University of Sassari, spending six months at the Chemical Engineering Department of the University of Chile in Santiago of Chile, and six months at the Monolithos company in Athens, to study CO_2 methanation processes over Ni/(Mg, Fe, Ca) silicates. His PhD project was addressed to develop innovative strategies aimed at mitigating atmospheric levels of CO_2, indicated in the scientific literature with the acronym "CCUS" (*Carbon Capture, Utilization and Storage*); more in detail, the subject of study was the investigation of the *mechanochemically and thermally induced CO_2 transformation* into fuels with high commercial value such as methane. With regard to the very innovative mechanochemical activation process, attention was paid to implement a continuous flow-type mechanochemical reactor, which was then used to investigate CO_2 conversion, using, as reacting materials, H_2O and natural Mg, Fe, and Ca silicates, such as Olivine and Basalts, widely spread on the terrestrial crust and with a low commercial value. Processes were studied at atmospheric pressure and at

room temperature. The attention was placed on the investigation of the dependence of the reactivity on the different experimental conditions, such as the variation of mechanochemical parameters and the stoichiometry of the process. The study made use of a variety of instrumental investigation techniques, such as XRD, FT-IR, SEM, TEM, NMR, GC-FID, etc. for the analysis of the solid and gaseous phases and the mechanistic deepening. Results highlighted the transformation of CO_2 in the form of carbonates (mineral carbonation process) and the formation of light hydrocarbons such as methane, ethylene, and ethane in the gas phase. Processes were accompanied by the evolution of molecular H_2 produced *in-situ* from water, whose concentration by volume was high enough to allow the hydrogenation of CO_2 following an FTT *(Fischer-Thropsch-Type)* reaction. The mineral carbonation of carbon dioxide (in form of Nesquehonite ($MgCO_3 \cdot 3H_2O$) and Magnesite ($MgCO_3$)) already observed in mechanochemical processes in batch-type reactors, characterizes also the process carried out under flushing gas conditions. The main results of the research were reported in two patent applications.

A. Taras et al., International Patent application No. PCT/IB2022/052433, Date: 17/03/2022

Designing mesostructured bifunctional catalysts for dimethyl ether production from CO_2

Fausto Secci

Fausto Secci attained his Bachelor of Science in Chemistry at the University of Cagliari in 2015 with full marks Magna cum Laude; his internship work was held under the supervision of Prof. Carla Cannas with a thesis entitled "Titania nanoparticles design for application in solar cells". In 2018 he attained his Master of Science in Chemical Sciences at the University of Cagliari with full marks Magna cum Laude; his internship work was held during a five-month exchange period at ETH in Zurich under the supervision of Prof. Antonella Rossi and Prof. Nicholas D. Spencer. His Master's thesis was entitled "Nanostructured spinel ferrites: their characterization by surface techniques". In early 2019 he worked at the University of Cagliari on a project, covered by a research scholarship, focused on the synthesis of mesostructured materials by EISA (Evaporation-Induced Self-Assembly) approach, under the supervision of Prof. Carla Cannas. In late 2019 he started his PhD work at the University of Cagliari under the supervision of Prof. Carla Cannas; the project, funded by MUR in the "PON Ricerca e Innovazione 2014-2020" framework, is focused on the design and synthesis of innovative mesostructured bifunctional catalysts for conversion of CO_2 in DME (dimethyl ether). The project has been held in collaboration with Sotacarbo SpA, under the supervision of Dr. Mauro Mureddu and with the Humboldt University of Belin, in which Fausto Secci spent a total of five months (October 2020 and April-July 2022) under the supervision of Prof. Nicola Pinna. The project is focused on

the revaluation of CO_2 as a resource, rather than as a waste, in order to use it to produce DME, a fuel that can be used in diesel engines granting better performances and no emissions of SOx and aromatic compounds. The work can be thus included in the framework of Carbon Capture and Utilization (CCU), which is receiving increasing attention from the scientific community and the governments due to its potential in decreasing CO_2 emission by capturing and using it to produce chemicals and materials. CO_2 is converted into DME through two subsequent reactions: the first one is the reduction of CO_2 to methanol with hydrogen and requires a Cu-based redox catalyst, the second one is the dehydration of methanol to DME and is promoted by acidic catalysts. The PhD work has been first focused on the synthesis of mesostructured acidic catalysts for methanol dehydration and their characterization to assess their structural, textural and morphological properties, as well as their acidic features, essential to obtain good performances in methanol dehydration; catalytic performances have been eventually tested. Particularly, the attention has been focused on different mesostructured aluminosilicates, as well as on mesostructured γ-Al_2O_3, TiO_2 and Zr-TiO_2. The obtained data allowed to ascertain that aluminosilicates, due to the presence of Brønsted acidic sites, are much more active towards methanol dehydration than γ-Al_2O_3, TiO_2 and Zr-TiO_2, that only features Lewis sites. Also, the proximity (surface density) of Brønsted sites proved to be a key factor to improve catalytic performances. These catalysts have been tested in form of physical mixture with redox catalysts and in form of nanocomposite, with the redox phase inserted into their pores. In this context, physical mixtures showed better performances, presumably due to the coverage of the acidic sites caused by the deposition of the redox phase.

Cara C., Secci F. et al. On the design of mesostructured acidic catalysts for the one-pot dimethyl ether production from CO_2. J. CO_2 Util., 2022; 62: 102066.

PhD programme in Earth and Environmental Sciences and Technologies

Coordinator: Gabriele Cruciani
Vice-coordinator: Gianluigi Bacchetta

The PhD programme in Earth and Environmental Sciences and Technologies promotes the study of the Earth and its natural resources as well as the protection of the natural environment in its biotic and abiotic aspects, also with reference to the impact of human activities. The doctoral programme also supports research on new technologies, applications, and nature-based solutions as innovative tools for monitoring, preserving, protecting and regenerating the natural environment.

The leading topics of the PhD course, articulated into three curricula (1. Geological evolution of the territory; 2. Applied geology and environmental technologies; 3. Geosphere-biosphere interaction) comprise geosciences and georesources, management of physical and biotic environments, soil and subsoil, ecosystems and habitats, solid and liquid wastes, contaminated environmental matrices, secondary raw materials, etc.

Sustainable exploitation and recycling of resources, in a context of circular economy, are also primary objectives.

Integration between theoretical and applied, abiotic and biotic disciplines, from molecular to ecosystem scale observations and experiments are promoted throughout the entire doctoral programme in line with current international research trends.

The research and teaching activities include short courses and seminars, internships and stages in Italian and foreign universities/ research institutions, encouraging at the same time participation in national and international conferences and publication in scientific journals. Internationalisation is achieved through participation in international research projects by the PhD students and with co-tutorship with foreign universities.

For the XXXV cycle, the PhD Course consist of five PhD students, with one of them having applied for the Doctor Europaeus certificate, involved in research projects about groundwater management, phytoremediation in abandoned mines, mineral resources, and treatment of waste materials from mining and industrial activities.

Extraction and recovery of valuable elements from Red Mud through biohydrometallurgy

Anna Cozzolino

Anna Cozzolino was born in La Maddalena in 1994. She graduated in Environmental Engineering at UNICA in 2016 (cum laude). She got her Master's in Environmental Engineering at UNICA in 2019 (cum laude). She concluded with a thesis on "Biogas production from anaerobic digestion of sludge containing biopolymers" after six months at the Universidade Nova de Lisboa (Portugal) within the Erasmus+ program. She won a PhD scholarship in 2019 and has been attending the PhD programme in "Earth and Environmental Sciences and Technologies". In 2021, she has been a visiting researcher at the Complutense University in Madrid (Spain), where she worked with international researchers and achieved new scientific and professional skills. Currently, she is working on her PhD dissertation on the *Extraction and recovery of valuable elements from Red Mud through biohydrometallurgy.*

The research project derives from the contemporary need to evaluate alternative management options for potentially polluting metallurgical waste and to search for new sources of critical/economically interesting elements, thus responding to the increasing world demand. The incorrect storage of metallurgical wastes and their exposure to atmospheric agents can cause serious issues for both human health and the environment. On the other hand, metals primary ores are limited and not homogeneously distributed worldwide. Therefore, some guidelines and actions of the European Commission encourage a more

sustainable use of raw materials and the recovery of valuable elements from waste.

These goals can be achieved by using traditional treatments such as hydro-, pyro- and electrometallurgy. An alternative treatment is bioleaching, a biohydrometallurgical process based on the ability of microorganisms (i.e., bacteria and/or fungi) to leach metals via direct and indirect mechanisms, reducing the use of chemicals and requiring low energy supply, thus representing a cost-effective and environmentally sound approach. This study is focused on recovering metals from Red Mud (RM), a waste deriving from the alkaline extraction of alumina from bauxite by the Bayer Process. Metals can be bioleached under acidic conditions and later recovered, minimizing/reducing the RM pollution potential. Given the alkaline pH and the absence of any sulfides in RM, the acidic environment can be produced by heterotrophic microorganisms when supplied with an organic substrate. The aim of this study was to extract metals through bioleaching with the development of heterotrophic biomass without any external inoculum (enrichment). The experimentation started with tests in batch mode that were focused on studying operational parameters, such as temperature, solid concentration, leaching medium and pre-treatment (i.e., carbonation). Depending on these results, a system scale-up was tested, moving to a 5-litre sequencing batch reactor. This type of reactor allowed the biomass enrichment, with the subsequent pH decrease and metals extraction. As visiting researcher in Spain, the studies were more focused on recovery methods from leached solutions, testing the bio/sorption of Neodymium (Nd), a rare earth element which exists in RM and is relevant in several technological fields. Anna has discussed many of the results obtained during international conferences, which will be published in international journals.

Characterization of the CRM occurrences in ore deposits of Sardinia

Matteo Deidda

Matteo was born in Cagliari in 1991. He obtained his bachelor's degree in *Geological Sciences* in 2011, with a thesis focused on XRD and ICP-OES analyses on mineral specimens of the *Leonardo de Prunner* museum at the University of Cagliari. In 2019, he then graduated cum laude in *Geological Sciences and Technologies* at the University of Cagliari. His master's thesis was focused on the petrographical and mineralogical characterization of a tungsten-bearing mineralization in SW Sardinia. A few months later he won a position as a PhD student in the XXXV cycle of the *Environmental Sciences and Technologies* programme during which he had been a visiting student at the University of Geneva and the ETH Zürich in Switzerland and the Karlsruhe Institute of Technology and the University of Tübingen in Germany.

His PhD project is intended to be a further investigation on the natural occurrence of CRM (Critical Raw Materials) in some ore deposits of Sardinia, with a focus on a class of deposits named *skarns*. The so-called CRM is used by the European Commission to include raw materials that have a very high economic demand due to their supply risk and and their extensive use in industry. Skarns are a class of mineral deposits that have never been studied in Sardinia before. They form after quite complex reactions between carbonate rocks and magmatic and hydrothermal fluids, resulting in metasomatic processes under progressively lower temperatures, overprinting mineral assemblages and the formation of ore minerals. The ore minerals

include Zn-Pb, extensively exploited by former mining activities, but also tungsten, tin, molybdenum, indium, bismuth which have been previously overlooked and are now considered among CRM. To verify the presence of such elements and to further understand how the deposits formed, after broad sampling of mineralized rocks in mining areas he performed analyses like Reflected Light Optical Microscopy, SEM-EDS, cold-CL, QEMSCAN, EPMA and LA-ICP-MS during his period abroad. This set of analyses are essential to investigate the mineralogical and textural features as well as the major, minor and trace elemental composition of minerals, which are at the basis of a characterization of the mechanisms of formation of ore deposits. By doing so, we provided preliminary but essential constraints for further CRM mineral explorations in Sardinia.

Deidda, M. et al. Mineralogy of the scheelite-bearing ores of Monte Tamara (SW Sardinia): Insights for the evolution of a Late Variscan W-Sn skarn system. Min. Mag., 2022; 1-49.

Investigation on revegetation/phytoremediation of Campo Pisano abandoned mine area

Pegah Kharazian

Pegah Kharazian achieved her B.S. in Agricultural Engineering-Phytopathology at the University of Teheran, Iran, and M.Sc. in Environmental Management at the Science & Research Branch, Azad University of Tehran (2009). Her main interest is the remediation of heavy metal-contaminated sites. She started her career at University after her thesis on "*Investigation on purification of contaminated soil (Zn & Cd) by Alfalfa plant and compilation of managerial model for final disposal of contaminated plant*". Since October 2019, she continued her research activities as PhD student at the University of Cagliari, Italy. She spent six months visiting period (Nov 2021-May 2022) within the European program "Erasmus+Traineeship" at the Faculty of Science, Department of soil science and agricultural chemistry, University of Granada, Spain. Meanwhile, she presented at international conferences and attended training courses, the most prominent ones were EDUC Research online Seminar (2021), EGU European General Assembly (Vienna, Austria, 2022) and Sanai Sa Terra (Sassari, Italy, 2022).

Her PhD thesis entitled "*Investigation on revegetation/phytoremediation of Campo Pisano abandoned mine area"* focused on the geochemical, mineralogical and physico-chemical properties of the soil-plant system considering the capability of tree species *Pinus halepensis* Mill. growing spontaneously in Campo Pisano abandoned mine tailing (SW-Sardinia, Italy). The idea was to devise a sustainable, easy-to-replicate and cost-effective technique for the reclamation of highly contaminated

mine sites. The research moved from the investigation of Botanical (identification of the suitable metal tolerant plant), environmental chemistry (evaluation of metal contamination) and geochemical/mineralogical characteristics (assessment of morphological features and mineral composition) in soil and plant. During the first year, *P. halepensis* materials (roots, barks, wood and needles) and soils (in-depth and around the roots) were collected aimed at evaluating the main mineralogical characteristics, metal content, plant accumulation and translocation behavior. Further investigation was carried out at the University of Granada aimed at assessing the geochemical forms of elements through the BCR three-step sequential extraction method in relation to the physico-chemical and mineralogical characteristics of the soil in depth and the soil-root system. The results showed that Pb and Zn were less bioavailable for roots and often found in high percentages in the residual fraction, mainly in deep layers of the compost-amended soil. Further, for gaining useful insights on phytoremediation capability of plant, a six-month ex-situ experiment was carried out under the controlled condition of the Hortus Botanicus Karalitanus (HBK) greenhouse laboratory, Cagliari. Young pine seedlings were planted in pots aimed at evaluating plant ability to tolerate Zn, Pb and Cd concentrations in different substrates (not-contaminated, contaminated and contaminated one amended with compost) and to assess metals bioavailability and accumulation in plant tissues. The phytostabilization potential was evaluated through the assessment of plant survival, elongation and biomass production. The results indicated that *P. halepensis* tolerates high Zn, Pb and Cd concentrations, restricts their accumulation and translocation to the aerial parts and may be applied for long-term phytostabilization and revegetation processes in mine tailing site.

Kharazian P., *et al*., An integrated geochemical and mineralogical investigation on soil-plant system of Pinus halepensis pioneer tree growing on heavy metal polluted mine tailing, Plant Biosystems International journal 1-14 (2022).

Advanced hydrogeological characterization of the alluvial aquifer of the Muravera coastal plain

Maria Chiara Porru

Maria Chiara graduated in Geology and Land Management at the *Alma Mater Studiorum of Bologna* in March 2018. Since her bachelor's degree she has always dealt with problems related to groundwater contamination and to the management of groundwater in coastal areas. During her PhD, she worked closely with researchers from the US Geological Survey of Colorado and Wisconsin. She also spent a period abroad at the Deltares, an independent institute for applied research in the field of water and subsurface, for the development of a numerical hydrogeological model with iMOD-Python. She has presented her works at three international and six national congresses and got the *Ghiglieri Prize* for the best presentation of young hydrogeologists in September 2022.

Her PhD project is entitled "Advanced hydrogeological characterization of the alluvial aquifer of the Muravera coastal plain".

The drought and climate change are among the biggest problems currently facing us.

Coastal aquifers represent extremely critical systems. Many coastal areas, especially low-lying delta areas, have a high density population and host important economic activities. Their aquifers are subject to over-exploited and seawater intrusion. Climate change, including sea-level rise, is expected that will further exacerbate the vulnerability of these already sensitive areas.

Saltwater intrusion is a crucial environmental issue in the Muravera coastal plain (south-eastern Sardinia). This phenomenon has led to the salinization of water and the accumulation of salt in the soils, with the irrepressible loss of land traditionally used for agriculture, causing environmental and socio-economic impacts.

The aim of the work was to contribute to the definition of a sustainable water management system to assure the equilibrium between the freshwater inputs to the plain aquifer and the withdraws, thus containing the extent of saltwater intrusion.

A density dependent groundwater flow and coupled solute transport model was built for the plain taking into account input and output to the hydrogeological system. Three main tasks were developed to implement the model addressing the following questions: i) what is the amount of natural recharge? ii) how fast do the aquifer respond to the recharge? iii) where do the further recharge to the aquifer come from? iv) how do the salt wedge extend inland and at depth?

The Soil Water Balance code (SWB) and the Water Table Fluctuation (WTF) method were applied to estimate the natural recharge and the behaviour of the aquifer to the indirect recharge.

A monthly piezometric and electrical conductivity monitoring survey was carried out to recognize eventual trends, main contribution on aquifer recharge and salinization mechanisms. Water chemistry evolution and flow path were investigated through chemical and isotope analyses of $\delta^{18}O_{H2O}$ e $\delta^{2}H_{H2O}$, $\delta^{11}B$, $\delta^{18}O_{SO4}$, $\delta^{34}S_{SO4}$, $^{87}Sr/^{86}Sr$. Moreover, analyses of ^{3}H, ^{3}He, CFC-11, CFC-12 and SF_6 were carried out to date groundwater and to evaluate recharge time.

The SEAWAT based iMOD-WQ software developed by Deltares was used to implement the numerical model, which allows the simulation of groundwater management scenarios contributing to the sustainable use of water resources in the coastal environment, addressing human and environment needs.

Controlling dark fermentation of agro-Industrial waste for valued organic acids production

Stefano Trudu

Stefano Trudu was born in Cagliari on December 30, 1993. He graduated with Laude in Environmental Engineering at the University of Cagliari in 2019 (master's degree). After the master's degree, he had been visiting student at the National University of Ireland Galway (NUIG) with the Erasmus+ traineeship program. From 2019 to date, he is working on his Ph.D. research on the valorization of agro-industrial wastes for valued organic acid production. During his Ph.D., he spent 8 months at Universidade NOVA de Lisboa working on polyhydroxyalkanoates (PHA) production from cheese whey (CW).

His current research is focused on the application of dark fermentation (DF) of cheese whey for valued organic acids production such as lactic and volatile fatty acids (VFAs).

Cheese whey is the main residue of the dairy industry. It is characterized by a residual high carbohydrate content which makes it a suitable substrate to produce value-added compounds through DF. The main goal of the doctoral thesis, titled "*Controlling dark fermentation of agro-industrial waste for valued organic acid production*", is focused on the identification of the operating parameters which affect the reactions occurring during DF to engineer the process itself for the production of specific organic acids useful in several applications.

For this purpose, two specific applications were investigated: PHA production and metal leaching.

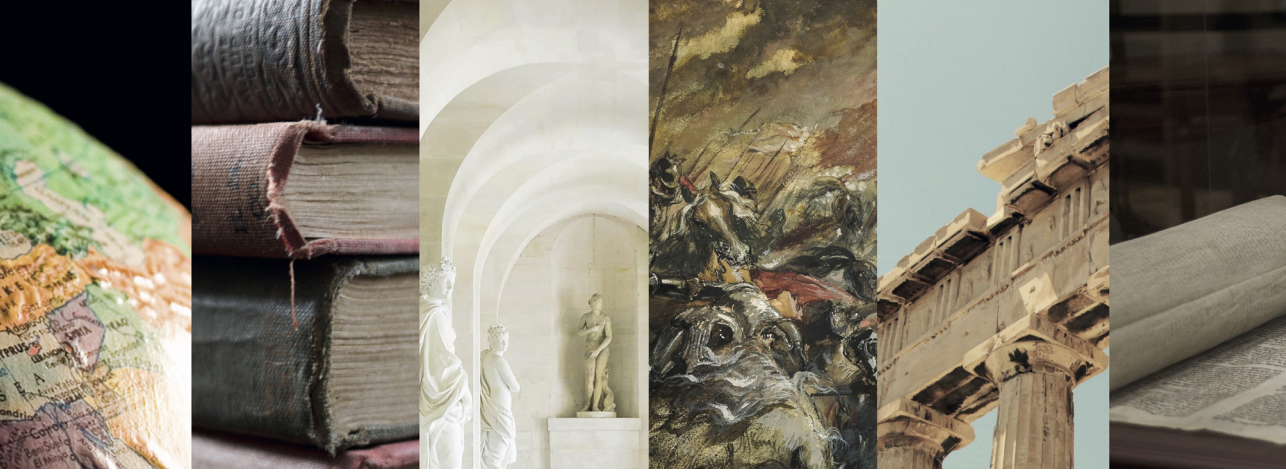
1) Polyhydroxyalkanoates are biopolymers synthesized by several microorganisms as carbon and energy reserves in the event of carbon excess and nutrient deficiency. Industrial production of PHA remains constrained by production costs up to five times higher than those of petroleum-derived plastics. In this framework, to reduce production costs, PHA can be produced starting from waste material as feedstock and using mixed microbial cultures (MMC). For this reason, in this work, cheese whey was used to produce PHA through a 3-phase process: i) fermentation, ii) culture selection and iii) PHA accumulation.

2*) Critical metal leaching and recovery.* Besides PHA production, organic acids produced through DF were used to recover metals from waste from electrical and electronic equipment (WEEE) through leaching process.

Electrical and electronic equipment (EEE) is increasingly part of our life and contributes to improving the quality of life by providing benefits and opportunities in various sectors. At the same time, EEE production requires a high number of resources.

Specifically, printed circuit boards (PCBs) and small IT equipment samples were treated for metal recovery (i.e., lead, tin, iron, nickel, zinc) using a leaching mixture produced from an appropriately controlled DF of CW (object of the Italian patent filed by Serpe et al., 2022 - Deposit N. 102022000007502, 2022). These scraps, indeed, contain a large amount of base, noble, and "rare earth" metals that can have a high value for the market or can be dangerous for human health and the environment when improperly managed.

Serpe, A., De Gioannis, G., Muntoni, A., Asunis, F., Spiga, D.; Oumarou Amadou, A.; Trudu, S., Cera, M., 2022; "Processo per la produzione di una miscela lisciviante da scarti di prodotti caseari," N. deposito italiano 102022000007502, 2022.



PhD programme in History, Cultural Heritage and International Studies

Coordinator: Lorenzo Tanzini
Vice-coordinators: Barbara Onnis, Mariangela Rapetti

The international PhD in History, Cultural Heritage and International Studies aims to train highly qualified scholars within the studies of History in a very broad perspective, including the study of the written records, the research about the material sources (archaeological, artistic, cinematic, musical), the Area studies about specific contexts of the global phenomena (Africa and Asia). A special focus is devoted to the Sardinian history and its cultural heritage, aiming at the development of the territory and the enhancement of international relations.

In the framework of this general organisation, the PhD is subdivided into three curricula (International and Area Studies. History. Spaces. Society; Euro Mediterranean Historical Studies from the ancient times to the contemporary era; Archaeological and Artistic Heritage, Film and Music Studies), which encourage the candidates to nurture, within the History guidelines, specific and original research directions with a comparative approach. The shared interests and the common work of the PhD students in such a multidisciplinary context is a powerful reason for crossing and comparing different disciplinary approaches in the current practice of their research.

Teaching is thus structured in several educational stages offering a basic research methodology in humanities, with a focus on the connections between different eras and geo-cultural areas, also from an interdisciplinary perspective, and a special interest on the digital methodologies in the fields of humanities. At the same time the educational path provides the PhD candidates with a valuable wealth of knowledge and skills regarding the management and promotion of historical and cultural heritage, the financial resources in the field of research, the development of European and extra European projects.

The international relations of the PhD Programme enable the students to develop specific experiences in different context of the European and global network of universities, as the case of the XXXV Cycle here presented clearly witnesses. The work of the students of this cycle represents an excellent example of the variety and the high quality of the research carried out within the PhD Programme.

https://corsi.unica.it/dottoratosbcsi/

Artistic women patronage in Medieval Sardinia Age

Valeria Carta

Valeria Carta holds a bachelor's degree in Cultural Heritage, then a master's degree in Archaeology and Art History from the Faculty of Humanities of University of Cagliari with a thesis in the history of Medieval Art dedicated to Cistercian architecture in Sardinia, under the supervision of prof. Andrea Pala. Since 2015 she has been collaborating with the Chair of History of Medieval Art, as a tutor. She is a subject expert at the Faculty of Humanities of University of Cagliari. She is an editorial board of ABside, Rivista di Storia dell'Arte, international art history academic Journal of the University of Cagliari. The research activity was carried out by attending conferences in Italy and United Kingdom, as a speaker. During her PhD course she spent six months at the Centre for Early Medieval Studies in Brno for a period of study and research abroad. In Czech Republic she could focus on different methos of research and improve her English abilities. The printed and digital publications reflect the main research interests: iconography, medieval sculpture and architecture with particular reference to Cistercian order. Valeria, also, has published articles in peer-reviewed journals, reviews, as well as contributions in multiple-authors books.

Her present PhD research focuses on *Artistic patronage and women commission in Medieval Sardinia Age (X-XIV centuries)*. In Sardinia some written sources testify to the presence of a significant number of women associated with the commissioning of works of art. Female names appear in relation to artistic patronage, like architectural, pictorial,

sculptural and sumptuary works. These clients probably were part of the aristocratic families that ruled the island. In most cases they are queen or nuns, in general noble people. The project proceeds from the analysis of written sources and material documentation to define the role of this female figures as clients of some medieval Sardinian works of art. In addition to this the study of written sources are important to compare works of art still present in the Island or, unfortunately only mentioned in the sources and now no longer existing.

The research starts from many medieval fragments recovered in currently destroyed churches which frequently recognized as out of context. The Greek-Sardinians epigraphs reports the men and women names who probably were part of the aristocratic families that ruled the island. It could be possible that they are men and women who committed these artefacts.

In the following centuries there are several evidence that could support the research regarding the gender commission related to noble women. Preliminary study attests that female names appear in relation to artwork, as sculpture or churches. These women would be patrons, who probably belong to the aristocratic families.

The investigation into the role of women as clients will be functional to understand the historical-artistic dynamics in Sardinia Medieval Age. Moreover, it can be clarifying the position of female figures in the decorative choices. Additionally, it might be significantly effective in order to reveal all the connections between artistic patronage and women in Sardinia. Also, comparing Sardinian evidences with other regions of Europe it could be advantageous for the analysis of the period.

Valeria is the author of the monograph:

Carta V. Santa Maria di Corte a Sindia. L'architettura Cistercense in Sardegna. Ghilarza: Iskra; 2019.

«Digital portraits»: for a multimedia tool on the teachers of the Royal University of Cagliari

Laura Cogoni

Born in Cagliari, in 2017 she graduated with honors in Cultural Heritage, archival-documentary address at the University of Cagliari. From September 2015 to June 2016 she participated in the Erasmus Studio+ program in Seville, where she deepened her studies on Spanish archives. Subsequently, in April 2019 she obtained the Master's Degree in History of Art with honors, with a thesis relating to the history of the Faculty of Physical, Mathematical and Natural Sciences of the University of Cagliari through the documents preserved in the Historical Archive of the University, which was later published. In October 2019 she won a PhD scholarship (POR-FSE) with the project entitled *«Digital portraits»: for a multimedia tool on the teachers of the Royal University of Cagliari (1764-1946).* The research project, carried out under the supervision of Prof. Eleonora Todde, intended to enrich the knowledge of the history of the University of Cagliari and the contents of the portal of its Historical Archive, through the creation of a relational database concerning the professors who they taught starting from the re-foundation, which took place in 1764, until 1946, the year of the cessation of the Royal University. The idea of creating a database summarizing the university careers of the teachers who taught at the Cagliari university was born, first of all, following the numerous requests to find information on this topic; secondly, following the observation of the difficulties that the user and the archivist encountered in extrapolating the data. The database was designed and created with the intention of facilita-

ting the widest access, for historical purposes and to facilitate research, to the data relating to the teachers of the city university contained in the rich documentary heritage available. The construction of the database was possible thanks to an analysis of the historical and regulatory context, elements necessary for the planning, compilation and choice of which fields to make available to users, and to a careful study of the sources, identified mainly in the Historical Archive of the University, in the Historical Archive of the Municipality of Cagliari, in the State Archives of Cagliari, in that of Turin, and in the Central State Archives, which preserve the documentation concerning the research object, and by means of a careful filing of the documentation according to the international standard of description ISAD (G), as well as an in-depth collateral bibliographic research to fill any gaps of the documentation. This work aims to guarantee an innovative tool and provide users with detailed and analytical texts so that access to primary sources is not reserved only for the various communities of scholars and intellectuals, but also for those who want to carry out a simple research and do not have archival skills. The digital database is built in such a way as to lend itself to the use of a target of scientific users, but with the possibility of easy access thanks to the search keys that will allow everyone to use it, constituting in fact a source accessible to professionals and to the public, both present and future.

This project naturally integrates with that carried out by Dr. Valeria Zedda during the three-year period 2017-2020 as part of the doctorate in History, Cultural Heritage and International Studies of the University of Cagliari, which created the database of students of the Royal University from end of the seventeenth century until 1946.

Cogoni L, Todde E, Tasca C. La Facoltà di Scienze fisiche, matematiche e naturali nell'Archivio Storico dell'Università di Cagliari (1848-1900). Dolianova: Grafica del Parteolla; 2020.

The military dictatorship in Brazil and the photojournalism (1964-1985)

Thomas Dreux Miranda Fernandes

Born in São Paulo (Brazil), after two bachelor's degrees (History and Journalism - 2011), a master's degree also in History, obtained through the study of the Brazilian diplomacy discourse during the military regime (2016); while working as history school teacher and photographer, the interest in studying the discursive strength of the images had grown. In so, the PhD project presented to UniCa it was the convergence of several personal, professional and scientific interests. The work *The military dictatorship in Brazil and the photojournalism (1964-1985)* it is centered on the role played by photojournalism during the dictatorship. The aim was to understand how the relationship between the newspapers «Folha de S. Paulo» and «Jornal do Brasil» with the military, in power for two decades, evolved. The hypothesis was that both newspapers elaborated a dialectical process of discursive reorganization on what the dictatorship was, reveling consequently, an updated attitude towards those who governed the country and how it was enunciated. The enunciation elements analyzed were centered in the uttering of the historical facts, but also on how the newspapers framed themselves as enunciation productors. Starting in the night between March 31st and April's 1st of 1964, Brazil had been under a reactionary, conservative and right-wing military dictatorship until April's 1985. A first overall notion of a Military Dictatorship might lead to the conception of a scenario mediated by a physical and material violence. Although it is truth, there are many more layers of authoritarianism into what might supposed to mean a Military government. The pro-

posal was then to analyze how the photojournalism was inserted in a context of a multifaceted spiral of violence and authoritarianism; in which in different opportunities the mass media press practice was included, even if with an apparent discourse that indicates the opposite.

In an overall the research has been divided in two main stages, the first year dedicated to the organization of the research corpus, the study of the state of art bibliography and the theoretical/methodological bases. The following two years were focused mainly on the analysis of the image's and in the thesis writing. In a world context affected by the pandemic, only in end of 2021 the presential participation Conferences and Seminars became possible, before of it were deepened and exploited the online alternatives. During the research period abroad, at the Universidade do Minho (Braga - Portugal), it was possible to be closer to debates and reflections releated to the news production practices, these were carried out in Portuguese, which in being my mother language, gave a new breath to the research unfolding.

Along the research were verified significant changes that occurred during the period under consideration, first and foremost the extensive use of images, were a response to the increasing complexity of relations inside the Brazilian society. Given the centrality of discursive production as a useful tool to achieve certain political and economic objectives, the photograph language and the verbo-visual tools interaction in the pages of newspapers were analyzed in a dialogical key, resorting to certain categories and concepts present in the thought of Bakhtin's Circle and Antonio Gramsci. A main conclusion that emerged from the work it is that the pictures had a central role in the narrative reorganization, although, the most important element was the deepening of the verbo-visual interactions in its pages.

The development of the CSDP and the Intelligence Sharing as an opportunity for revitalizing the EU's Defense

Pietro Lucania

The candidate is an academic collaborator for the teaching of new technologies and computer science law at DIEE - Cagliari University, and of the "Diritto & Information and Communication Technology" (DirICTo), network of experts and professionals, in the field of IT Law and Legal Information Technology. He is also and a member of the Oxford University Strategic Studies Group (OUSSG). During the PhD research, he has been a speaker at several seminars and conferences in collaboration with the University of Cagliari ? Department of Social and Political Sciences. He published several academic articles cooperating with the Anvur scientific journals and International Studies Centres and researched the EU Defense and Intelligence. European Defense policy is transnational due to the interdependencies of globalized societies and needs a greater form of cooperation and sharing. Within these areas is the extent to which European intelligence cooperation should also be promoted. This is a susceptible field with many implications. For this reason, existing approaches to intelligence should be deepened and better developed. The theme of "Intelligence sharing" is an ambitious project for the EU members but hard to achieve, even though it could be considered the most crucial tool in the fight against new threats. The topic of this research, in addition to mapping the organisms that are part of these communities (defense and intelligence) relies on a framework of policy analysis to structure the challenges of intelligence sharing on the European level. It is argued that the EU's

capacity to produce its security intelligence is very low, depending on the sharing of intelligence by the national agencies. The conclusion is that the European intelligence community welcomes different intelligence cultures within it and focuses its activities on diffuse cooperation that faces the limits of national sovereignty, interoperability deficits, and difficulties in establishing institutional relationships of trust. Limits that are difficult to overcome.

The people of Sardinia: changes and adaptation through funerary rites

Rossella Paba

Rossella Paba obtained the bachelor's degree at UniCA in Cultural Heritage (2012) and after her master's degree in Cultural Anthropology at Milano – Bicocca (2015), she participated to a wide range of workshops, summer schools, and internships in biological anthropology, noteworthy the LABANOF summer school (UniMI), the participation in the AgEstimation project held by Prof Roberto Cameriere (University of Macerata), and the internship at Teesside University with Prof. Tim Thompson. Back home with these experiences she won a casual research contract under the supervision of Prof Carlo Lugliè for the biennial project "*Know the Sea to Live the Sea*" (Fondazione di Sardegna). Notable is the project "*A new lease on life: using advanced analytical techniques in bioarchaeology to maximise understanding of the prehistory of Sardinia*", which won the PhD scholarship of which professors Carlo Lugliè (UniCa), Tim Thompson (Teesside University, for the osteological part) and Carla del Vais (UniCa, for the Punic chronological context) are scientific and methodological tutors. The project combines biological, archaeological, and cultural data, with the application of new technologies. The people of two specific sites from the two key eras of Sardinian history, the Neolithic period, and the Phoenician/Punic eras, are of prime interest. Respectively, these are the sites of *Su Forru de is Sinzurreddus* in *Pau*, and *Monte Luna Necropolis* in *Senorbi'*. Thorough a biological analysis of each sample of human remains, with the application of advanced analyt-

ical techniques, such as chemical analyses both in elemental and molecular composition, 3D modelling, and GIS mapping, has proven to be effective. Additional information about health, rites, and funerary behaviour is presented. The data all together represents a new set of information to be compared across a wider perspective across Europe. The first results were published on the Journal of Archaeological Science: Reports with a paper entitled "*Rising from the ashes: A multi-technique analytical approach to determine cremation. A case study from a Middle Neolithic burial in Sardinia (Italy)*" (2021) which shows evidence of the most ancient known cremation in the history of the island. Thanks to the opportunities offered by UniCA in terms of international agreements and collaborations, Rossella Paba was also able to stipulate a co-supervision agreement for her thesis, under the Department of History, Cultural Heritage and International Studies and James Cook University (Australia), tutored by Prof Kate Domett (College of Medicine and Dentistry - CMD) and Dr Anna Willis (College of Social Sciences). She spent 10 months (May 2022 – March 2023) at the Bebegu Yumba campus in Townsville where she improved her academic writing and editing skills in English, participated to seminars, and become part of the research project "*Human Biology and Health from the Neolithic to the Iron Age in Thailand*". During this time, she was awarded a competitive grant inside the CMD and a travel grant from the Australasian Society of Human Biology (ASHB). The latter had been awarded to participate as speaker for the 2022 ASHB conference held in Sydney in which she presented an osteobiography "*Life and death in the Monte Luna necropolis: the story of tomb n° 27*", concerning the skeleton of a woman of about 20 years of age, buried face down, with multiple traumas, hypothetically due to the possibility that she suffered from epilepsy and the results of a ritual which led to her death and unusual burial. The paper on Tomb 27 has also been accepted for publication and be available in 2023.

PhD programme in Civil Engineering and Architecture

Coordinator: Ivan Blečić
Vice-coordinator: Roberto Deidda

The PhD in Civil Engineering and Architecture places the built environment and the territory at the centre of scientific interest, understood as a complex field of research including the historical and contemporary built system, road and hydraulic infrastructure works, the environment and the natural and anthropised landscape, with particular attention to the interconnections between environment, economy, and society. The broad scope of research enhances an interdisciplinary vision of the issues addressed and favours the integration between basic and applied research.

The training course and doctoral research proposals are realised through theoretical, basic and experimental studies, which can benefit from technological support in instrumental laboratories for analysis and simulations of the various phenomena investigated, as well as the contribution of the Academic Board in the development of methodologies and models, in the quantitative analysis of natural and anthropic phenomena, in the study of materials and in the definition of processes in the field of engineering, architecture and technologies. The studies, conducted in collaboration and synergy with the international scientific community, are aimed at providing high-level multi-sectoral specialist contributions in terms of the advancement of scientific research but also at providing concrete answers to technical and opera-

tional problems in relation to sustainable development and territorial governance.

The cultural heritage of the Doctorate is manifested in the scientific production concerning, among the various themes, the recovery and enhancement of historical and contemporary buildings, the conservation and protection of architectural and landscape heritage, territorial, environmental and urban planning, the management of water resources and transport, the protection and safety of territories from adverse meteoric events, static security, with significant repercussions not only on the academic level, but also on the institutional and social level.

In this sense, the primary objective of the Doctorate is research training and the acquisition of methods and tools for conducting research projects in the disciplinary and interdisciplinary areas described above, together with the highly qualified teaching capacity.

Particular attention is paid to the consolidation of the capacity for autonomous elaboration of original research programs on the topics covered by the doctorate. The doctorate also pursues technical-operational objectives, consistent with the professional connotation and service to the territory of the disciplines of civil engineering and architecture, in which fundamental research is combined with applied research, with significant industrial and social repercussions. These objectives aim to strengthen the capacities of doctoral students to identify existing relationships and interconnections between engineering, architectural, technological, environmental, economic, and social aspects.

To accompany the path of doctoral research in the three-year period, the doctorate offers an articulated offer of introductory and advanced courses, as well as a rich programme of seminars, conferences, and laboratory activities together with interdisciplinary training, documented for the past years on the website (https://dottorati.unica.it/dotticar/).

The Doctorate organizes a six-monthly meeting of presentations of doctoral research, aimed at the collegial discussion of the progress also aimed at collecting from members of the Academic Board other than the designated supervisors. Furthermore, the Doctorate promotes in-depth seminars on individual doctoral research, at least one during the three-year course, organised by each PhD student and his supervisors, and with the participation by invitation also of scholars and prominent discussants external to the Academic Board.

The training program is also implemented through the opportunity to attend courses and seminars held also at other universities, specialisation schools or foreign offices with which exchange and reciprocity agreements have been stipulated, and through the mandatory research and study period abroad at universities and research institutions, of at least 6 months.

The advanced training acquired during the doctoral course and the constant stimulus deriving from the interdisciplinary context that characterises the Academic Board, contribute to the training of PhDs able to deal with complex problems concerning the management of the territory in its broadest sense, compatible with a sustainable development of the environment, the prevention and mitigation of natural risks and the sustainable use of natural resources.

In addition to the natural academic opportunities in Italian and foreign universities and research institutions, the experience gained during the research path makes PhDs particularly competent for managerial roles in public administrations with skills for operating in various capacities on the territory (for example in spatial planning; resource management, transport and mobility; protection, safety and protection of the territory and landscape), as well as for the vast area of the technical-professional and entrepreneurial private world that operates in the territorial and environmental field.

AIDforINFO - The Archive as an 'Information Industry'

Alice Agus

Alice Agus is an architect and PhD candidate in Civil Engineering and Architecture. Her interdisciplinary research, which involves the fields of Archival Discipline and Digital Humanities, focuses on the role of documentary sources in the processes of conservation, protection, and sustainable use of military historical architecture. After earning a master's degree in Architecture, Restoration address (2019), with a thesis on the restoration of vernacular earthen architecture, she dedicated her interests to the methods of collecting, storing, and accessing data on heritage. Currently, she carries out teaching support and research collaboration activities at the Department of Civil, Environmental and Architecture Engineering, in the scientific disciplinary sector ICAR 19 - Restoration.

Her Ph.D. research project, named *AIDforINFO - The Archive as an 'Information Industry'*, takes as its starting point an unsolved problem for Italian researchers involved in military architecture studies: the limited access to military archives, generally sealed, only partially digitized, and not adequately cataloged as regards to the architectural field. Indeed, these documents are essential for multidisciplinary studies on military architecture in terms of assessment of their different kind of cultural and economic values and, consequently, for their protection, conservation, and enhancement. For this reason, the research aims at investigating the role of the documentary source in the knowledge process and, contemporarily, at implementing the tools

for allowing 'intelligent' access and efficient queries into the contents, safeguarding the protection of sensitive data, but also enhancing the essential 'public' nature of the State Archives (*dual use*). It also includes the definition of protocols for the digitalization of Italian architectural military archives, especially the infrastructure ones, and the study of possible interconnections among several databases, including State Archives, Defense Cultural Institutes, and the Ministry of Culture Information systems (SIGEC, VIR, etc): part of the work then consisted of experimenting with the digitization protocol in use at the Ce.De.C.U. - 'Centro di Dematerializzazione e Conservazione Unico della Difesa' - based in Gaeta, with the goal of implementing the workflow by considering the testimonial and cultural value of the document.

The main objective of the research is the construction of the *AIDforINFO metadata set*, designed to extend selected standard ontologies (Dublin Core, ArCo - ICCD, etc) by integrating essential information for the knowledge and control of the military heritage, and functional for the construction of a Web Portal of the historical properties of the Defense. Since the research is funded under the National Operational Program on Research and Innovation (PON RI) 2014-2020 (Directorial Decree no. 1377), issued by the Italian Ministry of University and Research, this specific industrial goal is pursued in cooperation with the Italian company Leonardo S.p.A., a leader in the field of IT systems and services for Logistics Management dedicated to the Defense. The fundamental issues of accessing Military Heritage data, setting up the digitization process, and structuring the database were addressed during the research experience in Canada, at Carleton University, with the support of several institutions - particularly the Department of National Defense itself and Library and Archives Canada.

Implementation of complex historical elements in HBIM processes by algorithmic modelling

Raffaele Argiolas

Raffaele Argiolas graduated with honours in Architecture from the University of Cagliari. PhD student with research on the survey and modelling of historical elements for their implementation in HBIM workflows. Author of articles on digital survey and 3D modelling techniques applied to complex elements with the aid of parametric and procedural modelling tools. His topics of interest include the use of digital tools, such as augmented reality and virtual environments, for the communication of architecture and cultural heritage. Topics include the production of prototypes of portals for consulting digital models of artefacts and architectural elements, as well as some demonstrations of serious games and virtual tours. Since 2018, he has been carrying out teaching tutoring activities at the University of Cagliari, in the Faculty of Engineering and Architecture, for the activities of SSD ICAR-17.

The PhD research *Algorithmic modelling of complex historical elements. Implementation in HBIM processes* aims to develop an integrated workflow in current scan-to-BIM processes to integrate complex historical objects into these, eliminating or mitigating some of the critical issues that this integration entails at present. The core of the developed meth-

odology is the synergy of spatial data from laser scanner and photogrammetric surveys, geometric proportional rules from historical treatises, and the use of procedural modelling tools for the digital transposition of these historical rules. The research focused on the development of modelling algorithms that progressively evolved according to the case studies analysed and the treatises progressively integrated into the workflow. For a correct formulation of the process, the identification of the historical sources to be analysed and the tolerable error margins, the types of objects were identified upstream of the process, whose characteristics make integration in scan-to-BIM processes problematic, and possible applications for the generated models. Thanks to the progressive development of the algorithms, adapted and integrated to each new characteristic identified in the analysed objects, parameterised modelling processes were obtained that are capable of generating local models in the BIM environment that are typologically representative of the real objects. In the specific case of Gothic vaults, analysed in parallel by means of case studies in Sardinia and the Spanish region of Aragon, the procedural models proved to be largely morphologically valid as well; the calculation of the distances between the generated models and point clouds revealed, in the majority of the modelled areas, an error of less than 3-5cm; greater errors are almost always localised in portions of elements that had already been identified as problematic, such as the vaulting imposts. The errors obtained nevertheless proved to be tolerable for the possible uses initially assumed.

The medinas and cities in Middles Ages: Urban heritage, jurisprudence, traditions and built form

Meriem Ben Ammar

Meriem Ben Ammar is an Architect and a PhD student in Civil Engineering and Architecture at the University of Cagliari. She obtained her diploma from the National School of Architecture and Urbanism of Tunis and a Master's degree in Architecture. After graduating, her work was geared to housing rehabilitation and reconversion projects. Since then, she studied another Master's degree in Heritage sciences and Islamic archaeology in the Faculty of Humanities and Social Sciences of Tunis. Through this experience she won an Erasmus+ study mobility scholarship at the University of Cagliari, where she enlarged her knowledge of the history of the city and architecture, topography and above all the recovery of the architecture of historical centers.

The PhD program of the University of Cagliari offered workshops, seminars, courses and the possibility to spend two study periods abroad, one at the University of Antwerp, Belgium (Centre for Urban History) and the second at the University of Poitiers, France (Centre for higher studies in medieval civilization).

In this context, the candidate was able to develop her research methodology combining multidisciplinary approach, various study areas and specialties to carry out her thesis "*The medinas and cities in Middles Ages: Urban heritage, jurisprudence, traditions and built form*."

The research topic proposes to study the development of cities between the Middle Ages and the modern era in the Maghreb area and in southern Italy in the disciplinary field of the history of architecture

and the city. Through the analysis of a set of cities belonging to the Mediterranean corridor and sharing, in addition to political disputes, a common historical and cultural heritage, whose commercial transactions and the circulation of people have accentuated cultural exchange and generated a bilateral architectural and urban influence. The observation of the respective peculiarities or of the common rules of organization, as well as of the relationships that bind the various spaces of the respective urban fabrics, require a broad and articulated study.

This work intends to understand the functioning of the city, in medieval times, developed from the point of view of population, economic functions, spatial and social organization, and urban structure and its regulations. And its purpose is to examine various urban fabrics that highlight possible fields of comparison, of similarities in the arrangement of structures, in the normative or in the toponymic use.

A collection of legal and jurisprudential manuscripts and acts represent a first-hand source. It can be defined as rules and recommendations prescribed by the legislator to govern the architecture, urban planning, settlement, and development of the city. In addition to theoretical data of historical and legal type, graphic archives of Italian Architects and field work constitute a primordial phase in the observation of several urban fabrics and the comparison between them. The study envisaged an analytical part of the urban structures and of the cartographic and topographical aspects using the appropriate software for determining and recording the relationships between cities and above all between the similar urban components.

Ben Ammar M., La Giurisprudenza Islamica e l'organizzazione del tessuto urbano della città, Il Tesoro delle Città Collana dell'Associazione Storia della Città, 2019; 30-53.

Green infrastructures in wine landscapes: guidelines to planning

Giovanna Calia

I graduated in Agricultural Sciences at the University of Sassari, Sardinia, Italy. I wrote my thesis during a period at National Research Institute for Agriculture, in Nizza, France. This experience at the research centre made me passionate about the research community. After graduation, from 2019, I started my doctoral course in Civil Engineering and architecture at the University of Cagliari. The title of my doctoral thesis is *"Green infrastructures in wine landscapes: guidelines to planning"*. The research is focused on green infrastructures planning in viticultural areas through guidelines as planning tools, aiming to develop a correct planning approach for a success implementation and a future direct inclusion of green infrastructures in spatial planning processes.

My mobility abroad was held in Bordeaux, France, six months in 2021-2022, where I focused my case-study on urban vineyards in metropolitan city. Firstly, I studied the study context, in terms of strengths and weaknesses and institutional guidelines approved. Following, I defined main goals or general lines with actions and measures for achieve these. An important part of guidelines concerns the GIs design, which includes the comparation among three alternatives with respect to assessment of ecosystem services likely provided by each GI assumed, basing the designing on ecosystem services study. Especially, the ecosystem services assessed are cultural and regulatory, in terms of accessibility, at and from GI, and carbon dioxide sequestration. The ecosystem services whole is defined as net benefit with respect to cost,

obtained by comparing the different representative items with use of multicriteria analysis. A final reflection concerned a different preference of options proposed, hypothesizing the point of view of different stakeholders involved in choice, by applying the sensitivity analysis.

My research fits into the scientific panorama about the topics concerning nature-based solutions for obtaining services for well-being people and provide a valid methodological approach for planning GIs in viticultural, urban and peri-urban context.

The first application of method has been applied at the Metropolitan City of Cagliari in the scientific paper *"GI Guidelines for the Metropolitan City of Cagliari (Italy): A Method for Implementing Green Areas"* (Calia et al. 2021).

Calia, Giovanna, Antonio Ledda, Vittorio Serra, Giulio Senes, and Andrea De Montis. 2021. 'GI Guidelines for the Metropolitan City of Cagliari (Italy): A Method for Implementing Green Areas', Applied Sciences, Vol. 11; 10.3390/app112210863

Efficient and Intelligent Construction of Reinforced Concrete Shells

Alireza Hosseini

Alireza Hosseini started his Ph.D. program in February 2020 in Civil Engineering and Architecture at the Dipartimento di Ingegneria civile, ambientale e architettura of the University of Cagliari under the supervision of Prof. Luigi Fenu. His research is on form-finding and optimization of concrete shell structures and related technologies.

Previously, he accomplished his Master's in Earthquake Engineering at the Sharif University of Technology. He then entered the doctorate program at Porto University in Structural Engineering; however, that remained incomplete when he began his current position at Cagliari University. His doctorate program included eight months of research at Frem group, designing curved concrete reinforcements and studying the automation of bending procedures. The project involved collaboration with Fuzhou University, China, and remote working for six months due to travel restrictions.

The earth's population in 2050 is anticipated to be about ten billion people, which means that many buildings are required to accommodate people apart from renovating the current buildings. Therefore, new forms of construction are needed to accelerate the construction while using less material and emitting less pollution. The geometry of structural elements, especially shells, significantly impacts the structural elements' resilience and the entire structure reaction versus vertical and horizontal loads. Therefore, investigating the non-standard curvilinear shapes of reinforced concrete shells allows us to under-

stand them and employ more efficient forms and sections with higher strength and lower cost and waste. Thus, the Ph.D. thesis entitled *"Efficient and Intelligent Construction of Reinforced Concrete Shells"* focuses on detecting the deficiencies in unconventional curvilinear reinforced concrete shell design and construction. Furthermore, it investigates available solutions to strengthen the weaknesses of reinforced concrete shells by reviewing two essential subjects, 'optimization' and 'automation' in designing (analyzing) and construction.

Furthermore, the thesis project examines various methods to improve the reinforced concrete shell structural responses under seismic actions. Utilizing anticlastic curvature to enhance the geometrical capacity and structural control devices, e.g., dampers, to increase the ductility are evaluated via seismic performance analysis. In the latter, optimization of the proposed reinforced concrete shell shape and configuration is provided by exploiting the parametric design approach and simultaneous finite element analysis. The proposed techniques demonstrate improvement in structural measures based on the objectives.

Structural behaviour of edge-corrugated shells; inspiration from the Flaminio dome.

Matteo Lai

Matteo Lai is a civil engineer majoring in structural mechanics; he gained a bachelor's degree and a master's degree at University of Cagliari. He is currently a PhD candidate, and his field of research is buckling and post-buckling analysis of shallow shells under the supervision of prof. A. M. Cazzani, prof. V. Eremeyev and prof. N. L. Rizzi (UniTre Roma). His research interests span across shell structure mechanics, concrete shells, instability of shells, historical constructions, and masonry behaviour. Between 2021 and 2022, the research was conducted at the University of Stuttgart, Institute for Non-linear Mechanics, under the supervision of Dr Simon Eugster) for five months and just over a month at McGill University, Department of Mechanical Engineering (Montreal, Quebec, Canada) cooperating with prof. Marco Amabili.

The practical construction of reinforced concrete shells highlights two points, both of theoretical and practical interest: 1) in the neighbourhood of the edge, the membrane state is not representative of the actual stress and strain, and the effect of bending moments must be taken into account; 2) thin shells involve buckling and sudden snap-through instability, which designers commonly address by adopting simplified methods, based on the use of empirical knock-down factors. This research stems from an original building in Rome, the *Palazzetto Flaminio* dome, designed by A. Vitellozzi and P. L. Nervi for the Rome Olympic Games in 1960. This structure covers a considerable span, about 60 m; the cross section is thin (about 15 cm), and 36 inclined

pillars support it. To avoid the first problem, Nervi envisioned a structure with constant thickness, but its shape is slightly changed near the edge, so the shell is corrugated where an increase of stiffness is needed. The ongoing research deals with the instability problems and how this shape change can affect global mechanical behaviour.

Firstly, a geometric model of several corrugated surfaces suitable for civil engineering and architecture applications has been proposed. Secondly, the effect of corrugation at the edge increases the static performances: by making use of numerical analyses and theoretical comparison, a noteworthy decrease in the membrane stresses and in the bending moment has been ascertained, adopting a wavy shape.

Finally, the research investigated the buckling and post-buckling behaviour of the proposed corrugated shapes. The numerical analyses demonstrated the effect of increasing the safe load against elastic instability issues. Nevertheless, this result by Itself is not completely representative, because imperfections significantly influence the equilibrium path and, most importantly, are unavoidable. Therefore, analyses for the imperfect structure were performed, introducing each time customised imperfections (*e.g.*, local displacements or different reference states of the structure). The outcome shows that a clever shape significantly improves mechanical performance.

Given the recent advancement in concrete printing and the incentive for shape optimisation due to the fairly small thickness (in comparison with the span), instability must be carefully considered. Consequently, the pursuit of new shapes should be oriented towards the ones that provide intrinsically a significant improvement against edge-bending effects and sudden instability issues. The outcome of this research will provide foundations for structural analyses of corrugated surfaces, besides providing a new gaze for a different approach to structural optimisation.

Lai M. et al. Corrugated shells: An algorithm for generating double-curvature geometric surfaces for structural analysis. Thin-Walled Structures, 2022; 173: 109019.

Archaic Architectures. Typo-morphological invariants and principles of Nuragic space

Andrea Scalas

Andrea Scalas is an architect and Ph.D. Candidate in Civil Engineering and Architecture at University of Cagliari. His research *Archaic Architectures. Typo-morphological invariants and principles of nuragic space* focuses on the distinctive condition of the Nuragic archaeological heritage from a purely architectural perspective, in order to infer persistent values and spatial interpretations capable of making an innovative contribution to a modernized vision of prehistoric architecture and to detect some unchanging archaic principles from which contemporary design can still draw and learn.

The investigation is supervised by Professor Giorgio Peghin (University of Cagliari) and Professor João Gabriel Candeias Dias Soares (University of Évora) in the disciplinary-scientific areas of Architectural and Urban Design and Landscape Architecture.

The research hypothesis assumes that not only the condition of archetypal perfection of classical civilizations can rise as a model and reference to prompt contemporary invention, but also and especially prehistoric architectures, because therein lies the Agambenian possibility for the present. Through the conceptual category of the archaic, the overall objective of the research works on the identification of theoretical and operational tools useful for the reading, understanding and interpretation of contemporary architectures and places, in the belief that ancient architecture is the bearer of persistent instances. The structure of the research is made up of three parts: a first part in

which the theme of the archaic is probed through multidisciplinary contributions and approaches, in order to constitute a conceptual category of investigation, and its modes of manifestation and the primary operations of this interpretive code within architectural history are explored ab origine;

a second part, which analyzes the development of the archaic in the Mediterranean context up to the case study of Nuragic Sardinia, envisaging two different disciplinary voices that narrate from two different points of view nuragic architecture: the field of archaeology and the field of architecture. More space, in this sense, will be given to the critical contribution of architectural literature on the subject, going so far as to outline the reflections of great modern and contemporary masters, such as Rossi, Zevi, Rudofsky and Venezia;

a third part, critical, operational and experimental in nature, which introduces the theme of nuragic space according to a threefold view: first, through an anthology of typo-morphological principles of the architectures of the Nuragic culture, which systematize individual elements and relationships from the architectural scale to the territorial scale through the expressive tool of architectural drawing and representation; secondly, through a corpus of interviews conducted with artists with different profiles pertaining to architectural disciplines, from which some archaic constants that resurface to narrate the qualities of the Nuragic; thirdly, through the material construction of three physical models that represent the paradigm of the three Nuragic spatial recurrences.

Novel Neural Network Applications to Mode Choice in Transportation

Giovanni Tuveri

I received my master's degree in Civil Engineering in 2017 at the University of Cagliari, and I was lucky enough to start working as a Research Assistant at the same University very soon after. I had the opportunity to work on several research projects and learn from them. Most of these projects involved the study of passengers' mobility and the modelling of this complex phenomenon to better understand Its Inner workings. This inspired to start my Ph.D. research in 2019, by trying to find new ways to study how people behave when they have to make certain choices regarding their travel alternatives. During my three-year Ph.D. studies I had the opportunity to spend six months at *Danmarks Tekniske Universitet* (Denmark) to further improve my knowledge on the topics I was trying to understand and develop. My Ph.D. thesis is titled *Novel Neural Network Applications to Mode Choice in Transportation - Estimating Value of Travel Time and Modelling Psycho-Attitudinal Factors*. When researchers wish to study the behaviour of people choosing among alternatives, they traditionally rely on models based on the random utility theory, which says that individuals modify their behaviour to maximise their benefits. These models, called discrete choice models, require the definition of utilities for each alternative, by identifying the variables influencing their decisions. However, discrete choice models are rarely exempt from issues, like the fact that researchers have to choose the variables to include in the model and the relations to combine them with each other to represent the utilities.

This is probably one of the reasons which has recently lead to an influx of studies using machine learning (ML) methods to study mode choice in transportation. A machine learning algorithm is a method that uses the data itself to understand and build a model, improving its performance the more it is allowed to learn. The most known ML algorithms are Artificial Neural Networks, which are classifiers that mimic the network structure of the brain. There can be several possible structures, but they usually include a set of hidden layers and set of nodes in each hidden layer describing the structure of the network. ML models are considered black-box methods, but when researchers felt the need for interpretability, they tried to find alternative ways to use ML methods, usually by transforming their outputs so that they could be interpreted from an economic point of view. The object of my thesis was that of investigating the benefits and the disadvantages deriving from adopting either discrete choice models or Neural Networks (NN) to study the phenomenon of mode choice in transportation. First, I presented an alternative method for calculating, through the results of a NN, the value of travel time, which is a very informative parameter to be considered, since it represents the value that people place on saving total travel time. The method I proposed is independent from the mode-choice functions, so it can be applied to all models equally. Then, the other contribution of my thesis is a Neural Network method for the estimation of choice models with latent variables as an alternative to discrete choice models. This allowed to include in NN models not only level of service variables of the alternatives, and socio-economic attributes of the individuals, but also psycho-attitudinal indicators, to better describe the influence of psychological factors on choice behaviour.

Inside Coastal Paradox. A transdisciplinary approach to an unstable landscape

Maria Pina Usai

Attracted by the dynamics of interaction between landscape, architecture, art and society, I deal with transdisciplinary research for the sustainable development of the coastal landscape. After a bachelor's degree in Architecture at the University of Genoa and a master's degree in landscape, art and architecture at NABA Art Academy and Polytechnic University of Milan, I worked for the Coastal Conservation Agency of Sardinia. I co-founded U-BOOT Lab, a multidisciplinary platform focused on research in action on highly vulnerable landscapes, and MEDSEA Mediterranean Sea and Coast Foundation. I'm the creator and artistic director of Zones Portuaires Genova, a transdisciplinary project and festival focusing on the relationship between port, city and the sea, and Tunèa, dedicated to the re-connection between coastal communities and tuna fisheries.

The doctoral thesis starts from the assumption of recognizing in the coastal landscape a distinctive condition in comparison with other forms of landscape, and semantically declines it with the adjectival noun *Coastalness* (Kay and Alder, 1999; Buldrighini, 2013). The research aims at investigating the symbolic and strategic significance of it in order to develop an epistemological and methodological strategy useful to elaborate new critical and design approaches.

The starting focus is the extreme degree of complexity and dynamism of the littoral, the only place on earth where oceanic, terrestrial and

atmospheric processes interact simultaneously, in a space with shifting and permeable boundaries, subject to continuous variations of fluxes moving from the global to the local scale, and on which the effects of climate change are nowadays revealed in a significantly more visible and intense way than on other territories.

Although since the 1960s the international political agendas have developed specific tools to direct administrative processes and planning strategies, and stimulate public debate ad participation, the acceleration of the coastal landscape alteration reveals that their impacts are insufficient. At the same time, scientific research, too often isolated within its own knowledge, shows that it still has a marginal influence on policy makers and a limited effectiveness in spreading shared awareness.

It is therefore evident that study, design and manage through linear tools and static approaches a landscape whose defining characteristic is instability it's a paradox. In an era of profound and rapid changes dominated by anthropocentrism, it is therefore necessary to evolve traditional analytical, programmatic and planning methodologies through the development of flexible, experimental and transdisciplinary approaches, capable of reading, interpreting and communicating the dynamics of transformation of the coastal landscape in order to accompany its evolution.

In recent years, an increasing number of arts-based researches have begun to flank and support scientific research and political agendas in the process of investigating and monitoring the state of the marine, terrestrial and atmospheric environment and their reciprocal interactions: thanks to its ability to transcend the disciplinary boundaries of specialist fields and to contaminate the multiplicity of their respective approaches, the cooperation between art and science opens up new possibilities for interpreting, communicating and managing contemporary changes.

By placing inside an international frame of reference the personally conducted action-researches within two chosen experimental areas, the port of Genoa and San Pietro Island, the PhD research outlines the potential of the transdisciplinary research to take shape as an epistemological and methodological process useful for the elaboration of critical and innovative design approaches on the coastal landscape.

PhD programme in Electronic and Computer Engineering

Coordinator: Alessandro Giua
Vice coordinator: Giorgio Fumera

The *PhD Program in Electronic and Computer Engineering* (DRIEI: Dottorato di Ricerca in Ingegneria Elettronica e Informatica) of the University of Cagliari is offered by the Department of Electrical and Electronic Engineering (DIEE). It has been active since 1996 (XII cycle) and broadly covers the area of Information Engineering.

The PhD program is structured into two curricula.

- *Curriculum in Electronics and Telecommunications*, whose research topics span the disciplines of: Electrical and Electronic Measurements, Electrical Engineering, Electromagnetic Engineering, Electronics. Power Electronics and Electrical Drivers, Telecommunications.
- *Curriculum in Computer and Systems Engineering*, whose research topics include the disciplines of Automatic Control and Computer Engineering.

The program prepares for careers in high-technology environments, in Italy and abroad, including academia and international research centers. research management institutions. industrial research and development, consulting, and creation of technological start-ups.

The PhD program is internationalized and has formalized agreements with the School of Information Science of Southwest Jiaotong University (Chengdu, China) and the School of Electromechanical Engineering of Xidian University (Xi'an, China). In addition, theses in co-tutorship with other foreign universities are regularly activated.

Nine PhD students have been admitted to the XXXV cycle which started in 2019. All students are enrolled at UNICA.

The quality and consistency of the scientific activity is testified by the 20 papers on international journals and the 18 papers on international conferences that the students of the XXXV cycle have published so far, as part of their doctoral activities.

Optimization of Neural Networks for Embedded Systems

Paola Busia

Paola Busia received her M.S. degree in Electronics Engineering from the University of Cagliari in 2019. She enrolled as a Ph.D. student starting in October 2019, under the supervision of prof. Paolo Meloni. In 2022, she was a visiting student at the Integrated Systems Laboratory of Zurich's ETH, led by prof. Luca Benini. Her research activity is focused on the optimization and deployment of neural networks for resource-constrained systems.

Convolutional Neural Networks (CNNs) have become one of the standard approaches to computer vision, and have been also successfully applied, among other fields, to speech recognition and medical signals processing. The ability to learn complex data representation is obtained through complex architectures stacking multiple computational intensive operators, dominated by convolutions, which require the storage of a significant amount of trainable parameters. Despite such high computational and storage requirements, the growing success of CNNs has encouraged their deployment on a variety of different processing systems, including the edge-processing domain. This deployment scenario introduces tight resource constraints, requiring careful optimization of the classifier design and representing a very challenging task.

As the range of CNN-based applications grows, there is a need for efficient design solutions to assist the system developer in defining the optimal CNN architecture to meet the accuracy and performance

constraints. Despite the ongoing research efforts, the edge-oriented design still presents several challenges, given the huge design space of topological and processing possibilities involved in the optimal CNN selection, as well as the diversity of the hardware targets, exploiting computing units based on different architectural solutions. Thus, the design problem is often automated as an iterative search known as Hardware-Aware Neural Architecture Search, where the optimal CNN architecture for the task at hand is selected based on an accurate evaluation of the on-hardware performance accessed during the search process.

One of the subjects of the Ph.D. thesis *Optimizing Neural Networks for Embedded Edge-Processing Platforms* is the definition of a common unified method to pre-estimate the performance of the candidate networks on different hardware targets. The proposed method is capable of capturing platform-aware details, depending on the implemented dataflow and the embedded resources, and impacting the performance, such as the efficiency in exploiting the available parallelism, or the need to repeat some data transfers during inference execution. We evaluate the accuracy of our proposed method in comparison with alternatives requiring a similar, limited, development effort, showing a significant improvement. We reference two different target platforms, the NEURAghe accelerator, based on a hardware engine implemented on the FPGA, and the Jetson TX2 module, a system-on-chip (SoC) integrating CPU and GPU. Moreover, we consider an automated design process targeting the reference platforms, comparing different hardware-performance estimation methods to evaluate compliance with a set of user-defined latency constraints. The proposed method results in a final design very similar to the one obtained by accessing actual on-hardware measurements during the search process.

Busia P., Minakova S. et al. Aloha: A unified platform-aware evaluation method for CNNs execution on heterogeneous systems at the edge. IEEE Access, 2021; 9: 133289 - 133308.

The Art of Fingerprint Spoofing: ScreenSpoof and Adversarial Attacks

Roberto Casula

Roberto Casula graduated in Electronic Engineering at the University of Cagliari in September 2015. He then obtained the master's degree in Telecommunications Engineering at the University of Cagliari in February 2019 with a score of 110/110, debating the thesis entitled *"Statistical approach for Fingerprint Liveness Detection oriented to mobile devices"* under the supervision of prof. Gian Luca Marcialis. Since November 2015 he has been collaborating with the PRA Lab in biometrics field. The work done during his master's years and 3 years of PhD was based on the falsification of fingerprints and the Fingerprint Liveness Detection module. During the period abroad in Madrid (Spain) he was able to expand his knowledge in the field of adversarial perturbations and create a new type of mold printing with a 3D printer.

The title of my doctoral thesis is: *"The Art of Fingerprint Spoofing"*.

Analyzing the various problems that can arise from a direct attack on a certain device via a fake fingerprint, new attack models have been created to look for vulnerabilities in state-of-the-art liveliness detectors that use methods based on the deep learning. The first type of attack is that in which some of these traces are detected from the screen of a smartphone through a photo, thus carrying out an elaboration in order obtain a cast for the realization of the fake. In the best case, called *ScreenSpoof "in vitro"*, we will have an integral fingerprint that can be used to carry out an attack a biometric system or even on the finger ID of the smartphone itself. In the worst case instead, called *ScreenSpoof*

"in the wild" [1], we analyzed the various types of fingerprints present in a "dirty" screen. To evaluate the effectiveness of this method, the derived datasets were used as a test set of the best detectors of LivDet 2019 fingerprint liveliness competition (some methods based on deep networks and some methods based on handcrafted) and compared with their results obtained with the original dataset.

To further increase the danger of the attack, the second contribution of the project is aimed at modifying the result of the detector output class from false to live with an inconsistent *perturbation* that allows for pixel modification of the fingerprint image. By analyzing the print settings of a die on a transparent sheet, various techniques are studied which allow the appearance of an output corresponding to a real fingerprint, previously displayed as a spoof. Also, in this case perturbations were applied to false fingerprints acquired with a specific sensor, tested first with a detector whose characteristics are known and then with the best "closed box" detectors that took part in LivDet 2019 and LivDet 2021 competitions. The tests were done before with the disturbed fingerprints and then, subsequently, the mold for the creation of the fake physical was printed and, once the spoof was created, acquired with a different sensor from the original images, thus breaking into the field of interoperability. In addition to a cross-sensory analysis, a cross-material analysis was performed: the material used for the creation of false perturbed fingerprints appears to be present in LivDet 2017 training set, but absent in LivDet 2019 training set, thus putting in evidence the differences between detectors trained with known materials and detectors trained with unknown materials.

[1] Casula R. Towards realistic fingerprint presentation attacks: The ScreenSpoof method. Pattern Recognition Letters. 2022

Integrating Biological and Artificial Neural Networks Processing on FPGAs

Gianluca Leone

Gianluca Leone received his Master's degree in Electronics Engineering from the Politecnico di Torino, in 2019. In October 2019 he started his Ph.D. in Electronic and Computer Engineering under the supervision of Prof. Paolo Meloni. In 2022 he worked with the VLSI Design and Test Laboratory led by Prof. Amir Alimohammad at the San Diego State University, as visiting Ph.D. Student.

His research interests involve the development and optimization of neural signal processing systems and spiking neural network accelerators implemented on Field-Programmable Gate Arrays (FPGAs) and All Programmable System on Chip (APSoC) devices, i.e. integrated systems provided with programmable logic and ARM-based processing system, suitable for edge applications.

Understanding biological neural networks functioning principles and processing acquired neural samples aiming at decoding patients' intentions were widely researched topics in the past, and still are nowadays. However, emerging CMOS Multi-Electrode Arrays (MEAs) and High-Density Multi-Electrode Arrays (HDMEAs) changed the scale of the problem, if before the neural signal was acquired from tens or at most from one hundred electrodes, new generation MEAs and HD-MEAs mount thousands of recording sites, enabling wider area coverage, higher spatio-temporal resolution, and presumably will allow deepening the knowledge on biological units operating principles and will foster the design of more reliable neural prosthetic implants. The

augmented flow of data and the ever-changing experiment demands make FPGAs and APSoCs very effective instruments for hosting neural processing systems. Most of the operations can be mapped on Digital Signal Processing slices that are available in modern FPGA devices, whereas the Configurable Logic Blocks can be exploited to accelerate even the more specific portions of the neural signal processing, finally, the versatility of the Block RAM tiles comes in handy for reusing the same parametric hardware design with neural sensor arrays of different sizes.

With this aim, Leone et al. show a feasible solution for real-time low-latency neural signal processing over 5,500 recording electrodes on APSoC, embedding spike detection and spike sorting, i.e. spike identification within the neural track, and spike classification, a neural signal problem that aims to group the spikes fired by the same neuron basing the classification on spike waveforms similarity. The same neural signal algorithm is executed in real-time on each input channel, the most computing-intense steps, such as filtering and classification, are deployed on the programmable logic, whereas the ARM-based processing system takes care of refining the algorithm's hyperparameters sequentially on each channel. This setup permits reaching 82% accuracy, having a degradation of only 4 points when compared to the offline analysis, where the neural recording is entirely available and more sophisticated algorithms can be exploited.

The period abroad offered the opportunity to work on deep learning methods for neural decoding, a fundamental step to enable neural prosthetic implant design, since it permits bridging the gap between the spiking activity and the patient's intentions.

Leone, Gianluca, Luigi Raffo, and Paolo Meloni. "ZyON: Enabling Spike Sorting on APSoC-Based Signal Processors for High-Density Microelectrode Arrays." IEEE Access 8 (2020): 218145-218160.

Activity Recognition and Behaviour Analysis for Users' Quality of Life Improvement

Francesca Marcello

Francesca Marcello is born in Cagliari (Italy) in March 1992 and in 2019 she started her PhD in Electronic and Telecommunication Engineering at the Department of Electrical and Electronic Engineering, University of Cagliari. She was awarded with the master's degree in Telecommunication Engineering with full marks in 2019 at the University of Cagliari and since 2018 she works at the Net4U Laboratory of the Department of Electrical and Electronic Engineering of the University of Cagliari. Her research interests are especially related to Internet of Things, Smart Buildings and Human Behaviour Analysis. Her activity is mainly focused on studying solutions that, using different kind of sensors, devices, and systems, can lead to an improvement in users' life.

The two main topics addressed in her research are about Energy and Comfort Management inside intelligent buildings, especially Smart Homes; the other topic refers to the healthcare field. This last topic was also investigated the most during the 6 months visiting period abroad, at the University of Siegen, in Germany.

Human behaviour can affect, on different levels, the quality of life and there are many habits and behaviours for which a correlation with psycho-physical illness has been found. People often keep on carrying on harmful habits simply because they are not fully aware of them or because they do not know which would be a better alternative.

Therefore, monitoring, learning, and understanding human habits and how they influence one person's life, is very important and useful to provide users with tools that can make them aware of wrong behaviours and give them suggestions to discourage these habits and consolidate virtuous ones.

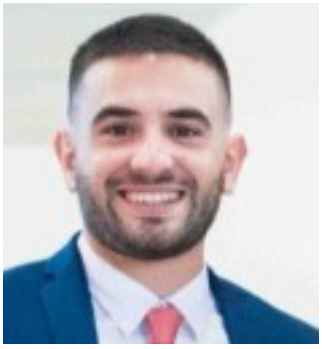
For this reason, the PhD study has been focused on the development of a solution that knowing users' daily habits is able to define which activities have positive or negative impacts on users' quality of life and advise them to undertake one of the positive activities when a bad emotional state is encountered. To this aim, the research conducted so far has been focused on monitoring the activities carried out by users inside their homes, considering a sensor-based Smart Home scenario, and studying their habits to propose an energy efficient system.

The system considers energy consumption and the user's comfort and preferences to find the best scheduling program for household appliances. Another aspect of this research work is focused on establishing whether these daily activities could be monitored using the most modern smart objects of daily use (smartphones, smartwatches, smartbands) and integrating them inside the same home scenario based on ambient sensors. Therefore, this new information and this data are used to establish whether there is a correlation between individual activities and particular stress levels or emotional states that have effects on users' psycho-physical health.

The obtained results are illustrated in the PhD thesis *"Sensors and Wearable-based Activity Recognition and Behaviour Analysis for Users' Quality of Life Improvement"* and they show how a more conscious use of energy inside buildings can guarantee energy savings while considering the user's comfort, and that, using common and commercial smart objects of daily use, is possible to find a strong correlation between simple data about daily activities and the level of stress and well-being of users.

Trustworthiness Management in the Internet of Things

Claudio Marche



Claudio Marche received the M.Sc. degree in telecommunication engineering with full marks in 2018 from the University of Cagliari. Since graduation, he has been working as a Researcher in the Department of Electrical and Electronic Engineering at the University of Cagliari in the Net4U research group. The topics covered the Internet of Things (IoT), Social Networks and Energy Management with particular applications in Smart Cities and Smart Buildings. He is currently a PhD student in Electronic and Computer Engineering at the University of Cagliari. His current research interests include IoT, Social IoT and Trustworthiness Management.

The IoT has become a reality with billions of devices able to send key information about the physical world, implementing simple actions, which leads to the paradigm of anytime and anyplace connectivity for anything. The massive amount of data flowing through the IoT has pushed forward the development of new applications in several domains, such as the management of industrial production plants, the logistics and transport supply chain, and e-health, just to cite a few.

However, IoT solutions have posed new challenges in the management of the amount of information produced. Indeed, searching for (reliable) time- and location-relevant information, services and resources for the deployment of running applications exploiting the IoT infrastructure is a crucial challenge: in addition to the size of the search space, most of the data produced by the sensors produce rapid chang-

es, making the system highly dynamic, as it happens for instance when tracking the position of moving objects. With such an interaction model, it will be essential to understand how the information provided by each object can be processed automatically by any other object in the system. This cannot clearly disregard the level of trustworthiness of the object providing information and services, which should take into account its profile and history. If not, attacks and malfunctions would outweigh these technologies' benefits.

In this regard, during the PhD studies, an exhaustive analysis of the trustworthiness management in the IoT has been proposed. To this, in the beginning, a dataset and a query generation model have been generated, essential to develop a first trust management model to overcome all the attacks in the literature. So, several trust mechanisms have been implemented, and the importance of the overlooked assumptions in different scenarios has been identified. Then, to solve the issues, the research has concentrated on the generation of feedback and proposed different metrics to evaluate it based on the presence or not of errors. Finally, the interaction between the two figures involved in interactions have been modelled, i.e. the trustor and the trustee, and the guidelines to efficiently design trust management models have been proposed.

The period abroad, which occurred in the Inria Lille-Nord Europe Centre in France, contributed to the PhD argument and provided a real-world scenario where trust management models could work in order to avoid communication breakdowns. As a result, a model for the new scenario has been proposed, which has provided a mechanism for wireless nodes to select the Wi-Fi channel in order to detect malicious behaviour.

The theoretical and experimental activities are explained in his PhD thesis: *"Trustworthiness Management in the Internet of Things"*.

Marche, Claudio, and Michele Nitti. "Trust-related attacks and their detection: A trust management model for the social IoT." IEEE Transactions on Network and Service Management 18.3 (2020): 3297-3308.

Traceability in complex food system

Lorena Mariani

Lorena Mariani obtained the bachelor's degree in Electrical and Electronic Engineering in 2015 and the master's degree with a thesis entitled *"Analysis of Empirical Models for Soil Moisture Estimation"* in Electronic Engineering at the University of Cagliari in 2019. In October 2019 she started her Ph.D. in Electronic Engineering and Computer Science at the University of Cagliari, under the supervision of Prof. Giuseppe Mazzarella and Prof. Alessandro Fanti. Her apprenticeship PhD, funded by the StudioA Automazione company, is inside the IAPC project, where IAPC is the acronym for Engineering and Automation of the Carasau Bread Manufacturing Process using IoT technologies. IAPC is a project supported by the Ministry of Economic Development in the framework of the Fondo per la Crescita Sostenibile "AGRIFOOD" PON I&C 2014-2020. The IAPC project has as its final objective the analysis and optimization of the artisan production process of Carasau bread using elements of Industry 4.0, academic knowledges, and core competencies. The title of her thesis is *"Traceability in complex food system"*. Her research interests include design and manufacturing of electromagnetic devices, such as RFID and NFC tag, for industrial process monitoring and the quality assurance, compliance and control systems for industrial applications, and especially in the bread manufacturing industry. Radio Frequency Identification (RFID) is a wireless technology mainly used to transfer data using the backscattered signal from an antenna. It al-

lows to identify and track a tag attached to an object. Also, Near Field Communication (NFC) is a wireless technology. It allows devices to establish communication with each other by touching or touching them together. RFID technology is appealing for several applications, such as logistics, identification, tracking and traceability, especially in the agri-food sector. RFID tags have already been proved to be a powerful tool for locating animals, monitoring and assessing food product or ingredient, while allowing to follow and track the entire history in the supply chain forward, from the source to the consumer, and backward, from the consumer to the source. For example, RFID systems have been used to monitor milk freshness, bacterial presence, by integrating the tag with humidity, gas, or temperature sensors. The RFID tools could be used at any point of a given supply chain (production, transportation, storage, and delivery). In order to propose a system to ensure a transparent traceability of Carasau bread supply chain, it has been proposed a blockchain based system for the supply chain management of the Carasau bread. Blockchain technology is a new paradigm for distributed ledger database that in the last few years attracted the attention of several companies due to the benefits that it could provide. Furthermore, ad hoc RFID and NFC tags were designed to shortly supply the proposed system with information about the products and batches, RFID antenna for the logistic operations related to the shipping and NFC tag for product tracking respectively.

Luisanna Cocco, Katiuscia Mannaro, Roberto Tonelli, Lorena Mariani, Matteo B. Lodi, Andrea Melis, Marco Simone and Alessandro Fanti, A Blockchain-Based Traceability System in Agri-Food SME: Case Study of a Traditional Bakery, IEEE Access®, Volume 9, 62899 – 62915, 2021.

Bio-WISE - Biometric recognition With Integrated pad: Simulation Environment

Marco Micheletto

I received my M.S. degree in Electronic Engineering from the University of Cagliari on September 2019, disputing a graduation thesis entitled "*User-specific effect in fake fingerprint recognition*". I then started my PhD under the supervision of Prof. Gian Luca Marcialis, within the Pattern Recognition and Application Laboratory (PRALab).

My research activity mainly deals with the study of fingerprint-based biometric systems, electroencephalography signal processing for biometric purposes and adaptive facial recognition systems.

During the three years of PhD, I focused on the integration of fingerprint verification systems with liveness detection systems.

Although biometrics are now commonly used, it is also true that they suffer from some limitations concerning large-scale applications. As a matter of fact, the project of any biometric verification system cannot ignore the vulnerability to spoofing or presentation attacks, which must be addressed by effective countermeasures from the beginning of the design process. However, despite significant improvements, especially by adopting deep learning approaches to fingerprint Presentation Attack Detectors, current research did not state much about their effectiveness when embedded in fingerprint verification systems.

The first goal of my PhD research was to address the lack of theoretical and experimental explanation of the integration problem, that is, model the cause-effect relationships when two non-zero error-free systems work together. For this purpose, a novel investigation tool

has been proposed: a performance simulator of the probabilistic relationships among variables at hand in the case of the sequential fusion of presentation attacks detector and matcher. Sequential fusion is only a possible choice, but it is also the simplest and widespread one. This simulator is called BIO-WISE and it has been made publicly available. It takes as input the receiver operating characteristic (ROC) curve of the fingerprint matcher and that of the PAD. The output is the whole acceptance rate in its three basic components: the genuine acceptance rate (GAR), the false non-match rate (FNMR), and the presentation attack acceptance rate (IAPMR). Two parameters are added: the probability of a presentation attack and the PAD's operational point. Using this simulator does not require implementing or replicate any PAD algorithm or matching system. This is also what a designer would prefer to do: take the vendors' individual ROCs and explore the performance achievable according to some expected scenarios, remarkably saving human effort and cost during the design process.

After verifying the reliability of the model in terms of difference between expected and real values, an extensive set of simulations was performed to derive the main guidelines to follow for deciding whether a particular PAD can be embedded in the matching process.

With BIO-WISE, we wanted to introduce a novel pathway worthy to meet the research community's interest.

In-depth detail can be found in my PhD thesis, entitled "*Fusion of fingerprint presentation attacks detection and matching: a simulated approach from the LivDet perspective*".

M. Micheletto, *et al.*, "Fingerprint Recognition With Embedded Presentation Attacks Detection: Are We Ready?," IEEE Transactions on Information Forensics and Security. Vol. 16. 2021. 5338-5351.

Quality of Experience network and service management on new generation Broadband Satellite Communications

Roberto Puddu

Roberto Puddu was born in Cagliari, Italy. He received his master's degree in Telecommunications Engineering in 2017, from the University of Cagliari (Italy) discussing a thesis titled "The DVB-T2 as a standard for mobile radio broadcasting". In the following two years he collaborated with the University of Cagliari within the Traffid+ project, during which a system was designed for the detection and automatic management of parking permits reserved for people with disabilities. Then he started his PhD in Electrical, Electronic and Computer Engineering at the University of Cagliari in 2019. The research activity of this PhD project comes from the collaboration between the University of Cagliari and the company Skylogic, the Italian branch of the Eutalsat group, one of the major European satellite operators, which provides both television broadcasting and broadband internet services. For this reason, his study focuses on the satellite broadband network and investigates how to improve resource management optimizing it in terms of Quality of Service and Quality of Experience. In recent years, also thanks to significant technological developments, the use of satellite networks has grown a lot. Many companies provide satellite broadband access that performs very similar to other access technologies. But in next-generation networks, the various access networks do not compete, but complement each other to provide global connectivity, even in the most remote areas. However, the major innovations introduced by 5G and 6G networks require satellite networks to per-

form better than current ones and incorporate features that have yet to be studied and implemented, such as traffic shaping techniques for QoS/QoE optimization and network slicing. But experimentation in the satellite field is complicated due to high costs. To remedy this limitation, the objective of this work was to collaborate with the Skylogic company for the creation of a simulator that would allow to reproduce the company's satellite network and, in the future, to implement various traffic prioritization mechanisms on it or, more generally, any new feature without having to use the real network and therefore at a low cost. Most of the development of the simulator was carried out during its period abroad at the Eutelsat teleport in Rambouillet (Paris), thanks to the collaboration with Alexandros Gkatzogianni, Business Intelligence and Special Projects manager, and Ciro Milite, Head of Digital Service Management and Monitoring of Eutelsat. The operation of the simulator was tested by implementing different types of traffic within the simulated satellite network and various queuing management mechanisms for QoS optimization.

Roberto Puddu, V. P. and M. M., "An open source satellite network simulator for quality based multimedia broadband traffic management," 2022 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Bilbao, Spain, 2022, pp. 01-07

Evaluating Robustness of Detection-based Defenses against Adversarial Examples

Angelo Sotgiu

Angelo Sotgiu was born in Bosa. He received from the University of Cagliari the Bachelor's Degree in Electrical and Electronic Engineering in April 2017, and the MSc degree in Telecommunication Engineering - with honors - in September 2019, discussing the thesis "Deep Neural Rejection against Adversarial Examples". His research interests include adversarial machine learning and computer security. He has been working on these topics with the Pattern Recognition and Applications Lab (PRALab) at the University of Cagliari since 2018, and he started his Ph.D. program in 2019, under the supervision of Battista Biggio and Fabio Roli. He was a visiting student at the CISPA Helmholtz Center for Information Security (Saarbrücken, Germany) from February to July 2022, under the supervision of Giancarlo Pellegrino.

Machine Learning algorithms provide astonishing performance in a wide range of tasks, including sensitive and critical applications. On the other hand, it has been shown that they are vulnerable to adversarial attacks, a set of techniques that violate the integrity, confidentiality, or availability of such systems. In particular, one of the most studied phenomena concerns *adversarial examples*, i.e., input samples that are carefully manipulated to alter the model output. In the last decade, the research community put a strong effort into this field, proposing new evasion attacks and methods to defend against them. However, a large number of these defenses reported overly optimistic evaluations,

whereas they have been shown to be ineffective against more sophisticated attacks, such as attacks that are aware of the defense mechanism. Therefore, the problems of defending machine learning models against adversarial examples and evaluating their robustness are still open.

In his PhD thesis, titled *"Evaluating Adversarial Robustness of Detection-based Defenses against Adversarial Examples"*, Angelo Sotgiu describes three different approaches that can be applied to Deep Neural Networks to detect and reject adversarial examples. The first leverages the domain knowledge of the relationships among the considered classes, integrated through first-order logic constraints. Within this setting, the classifier is able to reject samples that violate such constraints. This approach can be applied in both single and multi-label classification settings. The second one is based on a Deep Neural Rejection (DNR) mechanism to detect adversarial examples, based on the idea of rejecting samples that exhibit anomalous feature representations at different network layers. The third one is a technique for speeding up prototype-based detection methods by employing RBF networks as detectors. All proposed methods are evaluated in two different settings, i.e., against an attacker unaware of the defense mechanism, and against an attacker who knows the defense and adapts the attack algorithm to bypass it, respectively. For the latter, two novel adaptive attacks were developed. The experimental evaluation shows that the proposed methods increase the robustness of the defended models and help detect adversarial examples effectively, especially when the attacker does not know the underlying detection system.

Sotgiu A., et al., Deep neural rejection against adversarial examples, EURASIP Journal on Information Security 2020:5 (2020).

PhD programme in Industrial Engineering

Coordinator: Michele Mascia

The PhD programme in Industrial Engineering aims to provide doctorallevel education in key engineering areas of industrial relevance, with specific reference to the domains of Electrical, Mechanical and Chemical Engineering. The main objective of the PhD programme is training highly qualified researchers and professionals that could work independently and within a team, producing original and innovative research, promoting advancements in methodologies for analysis, processes and enabling technologies for real engineering applications.

During the three years, the PhD students are offered the opportunity of improving and acquiring, by a multidisciplinary approach, the knowledges, skills, and competencies required to meet the challenges and the opportunities of the current industrial progress in the international context. The programme includes attending advanced courses and lectures organised by the PhD school, as well as workshops and summer/winter schools. Dissemination of the results Is a key Issue of the programme, with presentations at national and international conferences and publications on scientific journals. The candidates are also required to spend research periods abroad to enhance and widen their scientific knowledge and cultural background in an international environment.

The work of the PhD students of the XXXV cycle represents an excellent example of the interdisciplinary research conducted within the PhD programme. The research activities have been carried out in cooperation with well-known foreign institutions and provide new insights

on specific themes including magnetic confinement fusion devices, the performances of Jet Engine Blades, power-to-methane systems, LNG recovery, energy production with renewable sources, and biotechnological processes.

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Artificial intelligence for the protection of magnetic confinement fusion devices

Enrico Aymerich

Ph.D. candidate at the Department of Electrical and Electronic Engineering, University of Cagliari, in the Electrical Engineering group. During his studies he participated in schools and internships at foreign research institutions and universities, in Lisbon, Prague, Greifswald, Culham, San Diego and Boston. He has authored publications in international journals or proceedings and serves as a reviewer for the journal Nuclear Fusion.

His research activity is aimed at the application of machine learning and data processing techniques for predictive and diagnostic purposes in the field of controlled thermonuclear fusion. During his DAAD grant-funded time abroad in Germany, he developed algorithms based on physics informed neural networks for calculating heat fluxes at Wendelstein 7-X, a stellarator experiment located in Greifswald.

His thesis "*Machine Learning and Deep learning applications for the protection of nuclear fusion devices*" describes the development of artificial intelligence and machine learning algorithms and is aimed at the protection of magnetic confinement fusion machines. Magnetic confinement fusion involves the use of magnetic fields to confine charged particles in field lines. However, in tokamak fusion devices, one of the main issues is the sudden termination of the experiment due to the sudden collapse of plasma energy. Such an event, called disruption, can be predicted using artificial intelligence techniques for analysing plasma parameters. In particular, the research activity involved the development of convolutional neural networks [1] for predicting dis-

ruptions at the Joint European Torus (JET). JET is the world's largest tokamak and the only one where experiments have been performed with the Deuterium-Tritium mixture, which will be the same as that used in ITER, the next-generation tokamak aiming to demonstrate fusion energy production feasibility.

In stellarators, on the other hand, the plasma tends to be stable, and the aim is to extend the duration of the experiment up to 30 minutes. In this context, the main problem is to monitor the integrity of the first wall of the machine, which, exposed to high thermal fluxes for long periods of time, is subject to the risk of localized melting and erosion. The code implemented at Wendelstein 7-X for calculating thermal fluxes, THEODOR, is not usable in real-time. Therefore, the research activity is based on developing methods for calculating thermal fluxes in real-time at Wendelstein 7-X, the world's most advanced stellarator. The algorithms developed are based on physics-informed neural networks, a cutting-edge line of research in which neural networks learn to approximate the solution of a partial derivative equation in a semi-supervised manner. The poster, "Physics Informed Neural Networks toward the real-time calculation of heat fluxes at W7-X," introduced the use of physics-informed neural networks for real-time-targeted fusion applications. The final model will be an extension of the presented one and will allow solving the heat equation from varying initial conditions. Neural networks are natively suited to parallel computation and implementation on the real-time control system graphics board (GPU).

[1] E. Aymerich, et al., Disruption prediction at JET through Deep Convolutional Neural Networks using spatiotemporal information from plasma profiles, Nucl. Fusion. (2022). https://doi.org/10.1088/1741-4326/ac525e.

High-Fidelity CFD Analysis of the Aerothermal Performance of In-serviced Jet Engine Blades

Mario Carta

I am a PhD candidate in Industrial Engineering from the University of Cagliari in Italy. In 2018 I have graduated with a master's degree in Mechanical Engineering, with a thesis on the topic of the numerical large-eddy simulation of the phenomenon of dynamic stall on moving aerofoils. The subject of my PhD is high-fidelity computational analysis of the flow in modern industrial jet engines. Since 2019 I have been conducting research on this topic within a collaboration with the "Future Methods" team of Rolls-Royce plc's civil aviation sector. My supervisor from Cagliari is professor Tiziano Ghisu and my industrial supervisor from Rolls-Royce plc is Dr. Shahrokh Shahpar. During my PhD studies, I have spent 18 months in Derby (UK) in Rolls-Royce's Moor Lane research centre. My case study is a widely used commercial jet (gas turbine) engine. In particular, I have worked on the high-pressure turbine stage. My primary focus is to apply high-fidelity computational Fluid Dynamics (CFD) analysis to study the engine's performance. I have developed and applied uncertainty quantification techniques to investigate on the correlation between in-service component damage and aerodynamic performance loss. This is the core part of my work, which has been published on the ASME Journal of Turbomachinery [1]. My work has also focused on conjugate heat transfer simulation, that is modelling the thermal exchange between the hot gas and the metal of some engine components, and unsteady modelling. For each of these two topics I have a dedicated paper that is current-

ly under review. The title of my thesis is *"High-Fidelity Computational Analysis of the Aerothermal Performance of In-serviced Jet Engine Blades"*

M. Carta, T. Ghisu e S. Shahpar, «High-Fidelity CFD Analysis of In-Serviced Shrouded High-Pressure Turbine Rotor Blades - TURBO-22-1122,» *ASME Journal of Turbomachinery,* vol. 144, n. 12, p. 121001 (12 pages), September 2022.

Techno-economic evaluation of Power-to-Methane systems, based on green H_2 and CO_2

Giulia Concas

Giulia Concas graduated in Mechanical Engineering at the University of Cagliari, in November 2019. She started her PhD Thesis "*Technical and economical evaluation of Power-to-Methane technologies, based on green H_2 and biogenic CO_2*", at the Department of Mechanical, Chemical and Material Engineering of the University of Cagliari, under the supervision of Prof. Daniele Cocco. She spent six months at the University of Southern Denmark (SDU) in the Department of Green Technology.

The main objective of her research is to analyse different plant configurations to simulate the conversion of Renewable Energy Sources (RES) electricity into green fuels, such as hydrogen and methane. Systems based on commercially mature or innovative technologies are analysed throughout the development of models to simulate each subsection and process and evaluate the performance of the overall system. The analysis carried out allowed the evaluation of the effectiveness and economic feasibility of such innovative technologies, Power-to-Hydrogen and Power-to-Methane. With the focus on the Power-to-Methane system, biological CO_2 conversion was chosen as the main process to produce biomethane, and different system configurations were developed, including different energy RES supply, different electrolysis technology, transport, and final CH_4 uses, etc. In general, the main sections for the operation of the system are an energy supply section, an H_2 generation section by means of water

electrolysis, a biogas generation section and a BHM section. The H_2 is produced by an alkaline or a PEM electrolyser, mainly fed by the electricity generated by a dedicated RES plant (Photovoltaic plant and/or Wind Farm). When the RES power is not available, the electrolyser is still fed by energy supplied by the electrical grid. The hydrogen can be directly injected into the bioreactor or stored in a dedicated tank to decouple the production of H_2 and CH_4. The pressure of the H_2 storage is set equal to the electrolyser operating pressure and therefore a compression section is not required in any configuration. The BHM process recovers the CO_2 produced by the biogas upgrading section of the anaerobic digester. However, the biogas can be directly injected into the biomethane reactor without an upstream upgrading system. Depending on the quality of the biomethane produced by the BHM process, may be required an upgrading section after the bioreactor, to achieve the gas quality required by the final users. Finally, the CH_4 can be injected into a dedicated pipeline or transported as LNG by trucks. In addition, as a case study, was considered the possibility to include such technology in the Sardinia energy scenario, one of the biggest islands in Italy, the only one without a natural gas grid and, at the same time, a high amount of RES energy surplus.

Environmental, economic and social impact assessment method of energy production projects based on renewable energy sources

Valeria Fois

Valeria Fois graduated in Civil Engineering at the University of Cagliari, in April 2002. She worked 20 years in a private company as a project manager gaining experience in the field of sustainable construction and renewable energy source. She started her PhD Thesis "*Environmental, economic and social impact assessment method of energy production projects based on renewable energy sources*", at the Department of Mechanical, Chemical and Material Engineering of the University of Cagliari, under the supervision of Prof. Daniele Cocco and Ing. Pierfrancesco Orrù. She spent six months at the University of Southern Denmark (SDU) in the Department of Green Technology.

The main objective of her research is to analyse the environmental, economic and social impact for design project in Renewable Energy Sources (RES). The innovative method, based on the analysis of the context, aims to empirically analyze some selected sustainability indicators. The proposed method starts from a detailed analysis of the wind power project, with particular reference to the plant site characteristics, technical features of the wind farm, opinions of the stakeholders, environmental and social impacts and expected economic benefits. The acquired data are validated with a several method like as Severity statistical method, circularity Indicator, Social Impact assessment, analytic hierarchy method, network analysis approach and LCA that identifies the KPIs. The indicators are classified into general catego-

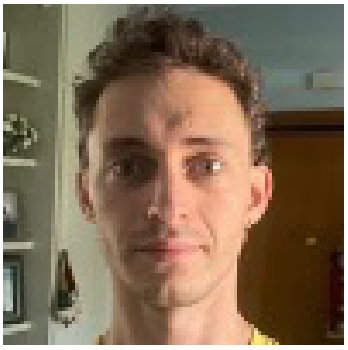
ries of damage. Public participation and analyzed through a combined SIA-LCA method to identify indicators damage weights.

The construction of an innovative method for assessing the sustainability of projects lowered on the context allows to determine the acceptance of the project and the possible interventions that can be implemented during the decision-making process. Sensitivity and scenario analyzes are thus carried out, evaluating the various criticalities that have emerged in the decision-making process.

Fois V., L .Lecis, Cocco D., Social impact assessment of wind power generation. An innovative method for decision making processes, 2022, in IOP Science.

Algorithms development for DEMO relevant scenarios studies

Massimiliano Lacquaniti



My name is Massimiliano Lacquaniti, I was born in Rome in the '93s. My field on interest is the nuclear fusion in tokamak devices. The tokamak are electric machines where a plasma made of hydrogen react to form helium, this reaction is called nuclear fusion and it is the main reaction that powers the stars. I graduated with a bachelor's degree in industrial engineering and master's degree in Mechanical Engineering at University of Study of Tuscia, in Viterbo, from 2013 to 2019. During this period, I spent a month at the University of Cagliari to complete a stage and my thesis about nuclear fusion.

After this useful collaboration, I decided to compete for a PhD grant at the University of Cagliari. During these 3 years of PhD, I frequented several courses and PhD schools about different Industrial Engineering research topics, such as magneto-hydrodynamic, Finite Element Methods (FEM) analyses, data acquisition, statistics, numerical methods and so on. Moreover, I spent a total of six months at the Max Planck Institute for Plasma Physics (IPP), in Munich, Germany. This period was really stimulating for me, I started collaborations with important researchers such as Hartmut Zohm, the research director of the IPP, who will be one of my thesis revisors. Before describing my research, I need to introduce DEMO: it will be the largest nuclear fusion machine and the first that will produce electric energy suitable for the population. My research is focused on the study of nuclear fusion scenarios interesting for DEMO, what we call DEMO relevant scenarios. Thus, the

title on my thesis is: "*Development of algorithms for the detection of plasma perturbations and for the characterization of magnetic field measurement errors in DEMO relevant nuclear fusion machines*". This is divided into three parts. The first one is the development of several algorithms able to extrapolate, from very large database of nuclear fusion experiments, the most interesting plasma perturbations and conditions in DEMO relevant scenarios, such as disruptions (an uncontrolled shut down of the machine), minor disruptions, Quasi-Double Null configurations (a configuration of strong interest for DEMO), plasma core tungsten accumulation and other plasma perturbations. The experiments selected in this way are used as input for 2D and 3D simulation. The second part of my thesis is focused on the Divertor Tokamak Test facility (DTT). It is the development of a FEM model to characterize the displacements due to the machine thermal dilations of the magnetic field diagnostic mounted on its wall. Finally, the core of the thesis is the development of a Machine Learning (ML) algorithm able to monitor the machine in a specific DEMO relevant scenario, the H-mode density limit. In this kind of experiments the plasma density is ramped to reach more interesting and attractive plasma conditions. Therefore, since the tokamaks present a technical limit in terms of plasma density, these experiments present several plasma perturbations such as the MARFE, a localized plasma instability. The goal of the ML algorithm is to observe in real time the machine status and to provide alarms related to the MARFE formation and its evolution as described in [1].

[1]: M. Lacquaniti et al, Identification of H-mode Density Limit key events by ISOMAP at AUG

Development of monitoring and control systems for biotechnological processes

Silvia Lisci

I was born in Iglesias, Italy, on October 22, 1992. I am a chemical engineer and a PhD student in Industrial Engineering. I received my bachelor's degree in Chemical Engineer and master's degree In Chemical Engineer and Biotechnological processes at University of Cagliari in 2016 and 2019, respectively. I started my PhD the same year, with the "*Development of monitoring and control systems for biotechnological process*" as research topic. This represents a very important problem since during a process, there is the need to measure and control parameters such as product concentration to understand if the process is going in the right direction. However, these measurements are difficult to obtain since there is a lack of sensors capable of providing this information in real time, especially for products or biomass involved in the process. Indeed, such compounds are usually identified by techniques that require both sample preparation and time to perform the measurement (GC, HPLC, ect.), which do not match the need for real-time information. For this reason, in Lisci et al. (2021) three different control strategies for a fermentation bioreactor were evaluated and analyzed. In particular, the cases of direct control of reactor temperature, cascade control with delayed product (ethanol) measurements, and an inferential control where ethanol composition measurements were reconstructed based on easily accessible primary measurements were considered. Still in the field of bioprocesses, another aspect that concerned my PhD work was the exploitation of food waste as biomass

for fermentation process aimed at the production of second-generation ethanol. This is what I studied in depth and experimentally performed during my period abroad at the University of Southern Denmark (SDU) in Odense. In particular, the spent grain from the production of beer was used as waste biomass, which represents the main by-product of this process. During this experience I organized and personally carried out the experiments of both acid pre-treatment on biomass and fermentation. It was an intense, very formative period that allowed to me to grow also personally. After my return, my research work focused on the analysis of fermentation samples collected at SDU by means of Raman spectroscopy. Since in a biotechnological process such as fermentation it is essential to have real-time measurements in order to guarantee product quality, while maintaining adequate performance and productivity, the ultimate goal of my PhD research is the development of a Raman spectroscopy-based sensor for real-time monitoring of ethanol produced and glucose consumed concentrations. Raman spectroscopy represents a very applied technique in this field because it is not time-consuming, and the samples are not damaged. The collected spectra were then analyzed whit statistical techniques in order to obtain a relationship between the characteristic peaks of the compounds of interest and their corresponding concentration. In this way, the models obtained will allow their composition to be evaluated in real time, thus enabling online monitoring of the process.

Lisci S, Grosso M, Tronci S. Different control strategies for a yeast fermentation bioreactor. IFAC-PapersOnLine, 2021; 54(3): 306-311.

Design Optimisation and Flow Characterisation for Future Aeroengine Axial Fan Blades

Diego I. Lopez

I am a PhD candidate in Industrial Engineering from the University of Cagliari in Italy. Previously, I completed a 5-year degree in Mechanical Engineering (Integrated MEng.) from the National University of Rosario, Argentina, in 2017 and a 2-year MSc in Aerospace Engineering from Kingston University London, UK in 2019. I been conducting research on the field of turbomachinery design optimisation since 2018, when I joined the Future Methods team at Rolls-Royce plc, and my PhD studies have been centred on this topic. My main area of interest lies at the intersection between physical modelling, computational design and statistical inference methods.

My PhD research has been guided by three supervisors: from Cagliari University, prof. Tiziano Ghisu, from Cranfield University, prof. Timoleon Kipouros and from Rolls-Royce plc, Dr. Shahrokh Shahpar.

Particularly, through my PhD, I have developed a design analysis framework for turbomachinery blades through which engineers can leverage the powers of artificial intelligence and high fidelity models to increase understanding of highly complex systems and identify design criteria that can lead to higher performing components. In my thesis, titled "*Design Optimisation and Flow Characterisation for Future Aeroengine Axial Fan Blades*", I develop this framework and exemplify

its capabilities through three challenging scenarios facing industry today. Each of these cornerstones of the research discussed in my thesis has been published in peer-reviewed journals, starting with the development of the framework discussed in [1].

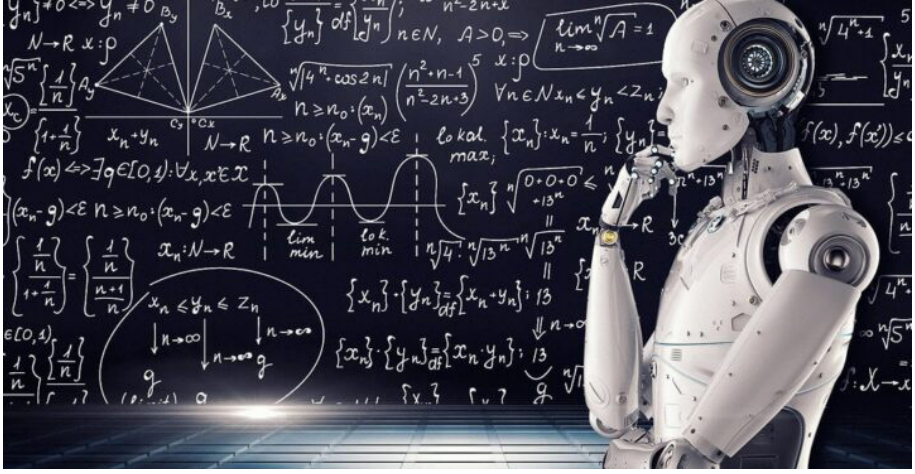
[1] D. I. Lopez, T. Ghisu and S. Shahpar, "Global Optimisation of a Transonic Fan Blade Through AI-Enabled Active Subspaces," *ASME Journal of Turbomachinery*, vol 144, n. 1, p 011013, September 2021.

Control and estimation for NGL recovery plant

Marta Mandis

I received a bachelor's degree in Chemical Engineering in 2015 and a master's degree in Chemical Engineering and Biotechnological Processes in 2018 both at the University of Cagliari. During my master's degree, I also benefited from the Erasmus+ traineeship mobility programme, during which I did an internship on the study, estimation and control of the microalgae growth process. In 2019 I started my PhD in Industrial Engineering at the University of Cagliari working in the research field of control of industrial plants and processes. During my PhD, I have spent two abroad periods, the first in Finland in the School of Chemical Engineering at Aalto University in Espoo and the second in Louisiana in the Cain Department of Chemical Engineering at LSU in Baton Rouge. Both experiences were focused on the application of machine learning techniques to industrial plants and processes. During my PhD, my research work has been focused on the control and estimation of an NGL recovery plant. NGL is the heavier hydrocarbon fraction contained in natural gas. The main reasons driving this research concern the fact that the NGL separation is not only necessary for transport issues but also provides an additional source of profit. NGL can be sold separately with a higher economic value as feedstock materials for different industrial processes. In addition, NGL removal leads to the reduction of CO2 emitted from natural gas combustion. The process considered was simulated on the Aspen Hysys process simulator. The study initially focused on the completion of the plant simulation to provide an

entire plant responsible for separating all the different hydrocarbon fractions in the raw gas. Subsequently, the work vested in designing control strategies to achieve maximum product quality without the use of composition analysers. Since the use of the latter has several disadvantages, they are expensive devices both in terms of purchase and maintenance. Moreover, their use introduces long delay times in the control loops. Given the necessity to provide information on the plant's target concentrations, once the control system was finalised, the focus moved to the replacement of measured concentrations with accurate real-time estimations. For this reason, deep learning techniques with a data-driven approach have been applied to develop software sensors for composition and process variables not easily measurable in a real plant but necessary for controlling the process. In the end, the research work centred on the design of neural models capable of simulating the time evolution of the variables involved in the process. The purposes were the obtainment of a digital twin to provide a useful tool for monitoring and control of the NGL recovery process. Deep learning methods were used to develop recursive neural networks responsible to model the separation conducted in all the distillation columns in the plant. The obtained models were able to accurately estimate the temperature, pressure and composition in all trays of the column using only easy-to-measure variables such as flows, temperatures and pressures. All the research activities will be included in my PhD thesis entitled *Monitoring and control for NGL recovery plant*.



Ph.D. Course in Mathematics and e Computer Sciences

Coordinator: Roberto Tonelli
Vice Coordinator: Antonio Iannizzotto

The XXXV cycle of the Doctorate of Mathematics and Computer Science saw the participation of twelve doctoral students in a traditional doctoral course, seven of which completed the full three years period while others asked for an extension. Six out of seven applied for the possibility to extend the Ph.D. course by three months, due to the Covid-19 epidemic. Among the seven Ph.D. students who completed the path in three years, one belonged to the mathematics curriculum, one to the big data curriculum and five to the computer science curriculum. In these three years, the doctoral students have carried out teaching support tutoring activities in various university courses and carried out the research path both in Cagliari and at foreign institutions.

Some doctoral students have carried out support activities for the organization of various projects organized by the Department of Mathematics and Computer Science. The firs and second years of activity were characterized and influenced by the Covid-19 epidemic which in some cases slowed down the regular research activity and changed the way of interaction between doctoral students, tutors and research groups. Six of the seven doctoral students have requested an extension to three months to complete the planned activities. Their

research produced several publications on international conferences and journals highly ranked among the scientific community.

https://dottorati.unica.it/matematicaeinformatica

Scalable Exploration of Complex Objects and Environments Beyond Plain Visual Replication

Moonisa Ahsan

Introduction

I, Moonisa Ahsan, am a PhD Candidate at University of Cagliari in the Department of Computer Science under the academic supervision of Prof. Riccardo Scateni. I also worked as Marie-Curie Fellow / Early-stage Researcher (ESR) under project supervision of Dr. Enrico Gobbetti, in the Visual and Data-intensive Computing (ViDiC) Group of CRS4, Italy from 2019-2022. My Doctoral Studies were supported by the Marie Skłodowska-Curie Fellowship under Horizon2020 ITN Project Evocation (81370).

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International Experience

I had the opportunity to work in international settings at CRS4 and UniCa while collaborating with various partners for scientific work across Europe. I collaborated with the Visual Computing Lab of ISTI-CNR, Pisa (VCLAB) to jointly develop a common tool base (OpenLime). My contributions concentrated on the design and usability aspects of the interface for the OpenLime viewer. I also presented our scientific work at workshops, conferences and project meetings.

Scientific Research

My research trajectory focused mostly on user-interaction methodology applied to 3D graphics. I studied modeling methods and interac-

tion techniques for permitting exploration of high fidelity 2D / 2.5D / 3D models annotated with semantic information. Researched topics included information modeling, rendering methods, and user interfaces. My particular case study was in the cultural heritage domain.

In my thesis, I addressed the main research challenges of how to effectively present a model under different angles, and how to communicate the auxiliary (geometric, conceptual and semantic) information. My main results and contributions to the state-of -the-art are (A) a novel technique[1] for interactively controlling visualization lenses while automatically maintaining good focus-and-context parameters, (B) a novel approach for avoiding clutter [1] in an annotated model and for guiding users towards interesting area, and (C) a method for structuring audio-visual object annotations into a graph and for using that graph to improve guidance and support storytelling and automated tours [2].

We demonstrated the effectiveness and potential of our techniques by performing interactive exploration sessions on various screen sizes and types ranging from desktop devices to large-screen displays for a walk-up-and-use museum installation. All this work is published and publicly available at https://evocation.eu/publications

[1] Fabio Bettio, et al., "A novel approach for exploring annotated data with interactive lenses," Computer Graphics Forum, vol. 40, no. 3, pp. 387–398, 2021.

[2] Moonisa Ahsan, et al., "Audio-visual annotation graphs for guiding lens-based scene exploration," Computers & Graphics, 2022.

Acknowledgements

I'd like to thank the National Archaeological Museum of Cagliari and its National Gallery, for access to the artworks for the purpose of digitization and for collaborating on our research work. This work has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Actions Innovative Training Network (MCSA-ITN) grant agreement No 813170 and my co-authors also benefited by the support of Sardinian Regional Authorities for projects connected to CRS4 Visual Computing activities.

Effects of Logic-Style Explanations and Uncertainty on Users' Decisions

Federico Maria Cau

Federico Maria Cau is a PhD student in Mathematics and Computer Science under the supervision of prof. Lucio Davide Spano. He earned a B.Sc. and M.Sc. in Computer Science at the University of Cagliari. During his second year of M.Sc., he worked as a research assistant in the AI4fit project and contributed to creating an intelligent interface for facilitating coaches in supporting their athletes. His research focuses on Artificial Intelligence and Explainable Artificial Intelligence (XAI) with applications related to Human-Computer Interaction. During his PhD, Federico worked on the RIALE (Remote Intelligent Access to Lab Experiment) platform, creating an intelligent interface which provides an AI tool that automatically tags objects and actions of didactic experiments while providing explanations of the AI's decisions. Since his first PhD year, he collaborated with the University of Maastricht, supervised by prof. Nava Tintarev, broadening his knowledge on the Explainable AI topic.

Federico's current research pivots around Explainable Artificial Intelligence, a field which tries to provide tools for supporting users in AI-assisted decision-making and uncovering the AI's error boundaries. The XAI community investigated numerous factors influencing subjective and objective metrics in the user-AI team, such as the effects of presenting AI-related information and explanations to users. There have been contrasting effects of presenting explanations observed in different works in the literature.

On the one hand, previous research demonstrated that explanations might cause users to follow the AI's advice more often, even when it is wrong, or lead users to create an incorrect mental model of the AI system. On the other hand, if we consider studies focusing on people having low domain expertise, we have results indicating overconfidence (users that rely mainly on their ability to make a decision) but also overreliance (users relying primarily on automatic support). In recent studies, a factor that gained attention is AI uncertainty in predictions, which quantifies how likely the AI will correctly classify an individual prediction.

In addition, other studies demonstrated that AI-related information like uncertainty and correctness may play a fundamental role in users' decision-making processes, but their effect also depends on experimental settings. Furthermore, uncertainty occurs also for users for many decision-making tasks, either due to the inherent (objective) complexity of the task, or more subjective and specific to the user and context (e.g., for previously unseen tasks). People are used to making decisions under uncertainty, which may also result in overconfidence in their decisions when making decisions about AI predictions. Finally, human-centered aspects such as presenting and selecting the appropriate explanation technique are usually overlooked in the literature. An underexplored topic concerns the reasoning style triggered by explanations, which results in an effective or ineffective understanding of the AI suggestions if not carefully selected according to the presented data. Previous literature in this field is sparse but includes attempts to classify the techniques into inductive, abductive, and deductive styles according to Pierce's theory, and highlighting different effects between inductive and deductive styles in the image classification domain.

Federico's thesis *Effects of Logic-Style Explanations and Uncertainty on Users' Decisions* is focused on identifying and presenting Explainable Artificial Intelligence techniques using logical reasoning styles coupled with different levels of user and AI uncertainty. Specifically, reasoning styles like induction, abduction, and deduction are investigated to understand how they affect users in the decisional process of a classification task on image, text, and time series domains.

Knowledge Augmentation in Language Models to Overcome Domain Adaptation and Scarce Data Challenges in Clinical Domain

Vivek Kumar

The co-existence of two scenarios, "the massive amount of unstructured text data that humanity produces" and "the scarcity of sufficient training data to train language models," in healthcare domain have multifold increased the need for intelligent tools and techniques to process, interpret and extract different types of knowledge from the data. My research goal in this thesis is to develop intelligent methods and models to automatically better interpret human language and sentiments, particularly its structure and semantics, to solve multiple higher-level Natural Language Processing (NLP) down- stream tasks and beyond. This thesis is spread over six chapters and is divided into two parts based on the contributions. The first part is centered on best practices for modeling data and injecting domain knowledge to enrich data semantics applied to tackle several classification tasks in the healthcare domain and beyond. The contribution is to reduce the training time, improve the performance of classification models, and use world knowledge as a source of domain knowledge when working with limited/small training data. The second part introduces the one of its kind high-quality dataset of Motivational Interviewing (MI), AnnoMI, followed by the experimental benchmarking analysis for AnnoMI. The contribution accounts to provide a publicly accessible dataset of Motivational Interviewing and methods to overcome data scarcity challenges in complex domains (such as mental health). The overall organization of the thesis is as follows: The first chapter pro-

vides a high-level introduction of the tools and techniques applied in the scope of the thesis. The second chapter presents optimal methods for (i) feature selection, (ii) eliminating irrelevant and superfluous attributes from the dataset, (iii) data pre-processing, and (iv) advanced data representation methods (word embedding and bag-of-words) to model data. The third chapter introduces the Language Model (LM), K-LM; a combination of Generative Pretrained Transformer (GPT)-2 and Bidirectional Encoder Representations from Transformers (BERT) that uses knowledge graphs to inject domain knowledge for domain adaptation tasks. The end goal of this chapter is to reduce the training time and improve the performance of classification models when working with limited/small training data. The fourth chapter introduces the high-quality dataset of expert-annotated MI (AnnoMI), comprised of 133 therapy session transcriptions distributed over 44 topics (including smoking cessation, anxiety management, weight loss, etc.), and provides an in-depth analysis of the dataset. The fifth chapter presents the experimental analysis with AnnoMI, which includes (i) augmentation techniques to generate data and (ii) fairness and bias assessments of the employed Classical Machine Learning (CML) and Deep Learning (DL) approach to de- velop reliable classification models. Finally, the sixth chapter provides the conclusion and outcomes of all the work presented in this thesis. The scientific contributions of this thesis include the solution to overcome the challenges of scarce training data in com- plex domains and domain adaptation in LMs. The practical contributions of the thesis are data resources and the language model for a range of quantitative and qualitative NLP applications.

Bio: Vivek Kumar received his M.S. degree from NUST-MiSiS, Moscow, Russian Federation. Currently, he is a Marie Sklodowska-Curie researcher with the University of Cagliari, Italy, and Philips Research, Netherlands. He is currently pursuing the Ph.D. degree at the University of Cagliari, Italy. His research interests include machine learning, deep learning, natural language processing, AI fairness, and BIAS applied to the healthcare domain.

A new evidence measure for Bayesian Inference

Mara Manca

Mara is a PhD student in the Mathematics and Computer Science Program, working under the supervision of Prof. Monica Musio. Mara completed both her undergraduate degree and her master's degree in Mathematics at the University of Cagliari. Her research aims to make a contribution to the Bayesian testing procedure of precise hypotheses for parametric models. In particular, her thesis *A new evidence measure for Bayesian Inference* is devoted to the definition and the study of the Bayesian Discrepancy Measure, a new Bayesian measure of evidence. In her first year, she was a visiting researcher at the Department of Statistics at the University of Padua, where she attended several PhD courses for the development of a solid statistics background. She was also a visiting researcher at the Department of Statistics at the University of Warwick. During her stay she worked with Prof. James Smith on the Bayesian estimation of probabilistic graphical models, within the class of indirect Gaussian graphical models.

A statistical hypothesis test is a statistical inference method that is used to test the goodness of a hypothesis. A hypothesis is an assertion about real-world events that can be confirmed or disproved by the experimental observed data. In the last sixty years there have been several attempts to build a measure of evidence that covers, in a Bayesian context, the role that Fisher's p-value has played in the frequentist setting. Fisher's pure significance test takes into account only

one hypothesis, in contrast with the decisionist approach where two hypothesis are fixed and the rejection of a hypothesis can be made only by comparing it with an alternative one (Neyman-Pearson approach in the frequentist perspective, Bayes factor in the Bayesian one). The Bayesian Discrepancy Measure, given the fact that it is a Bayesian evidence measure, provides an absolute evaluation of the suitability of a certain hypothesis in light of prior knowledge regarding the parameter and the observed data. The underlying idea of the Bayesian Discrepancy Measure is the assessment of this suitability by means of the measurement of the discrepancy between the posterior median and the hypothesis. Reference is made to a single precise hypothesis and no alternative is considered against it. In this respect, in a broad sense, the test based on the BDM returns to Fisher's original idea of pure significance. Furthermore, the proposed measure of evidence has the desired properties of invariance under reparametrization and consistency for large samples. Bertolino, F. et al. present several examples where it is evident the conceptual simplicity of the BDM as well as its theoretical consistency. The procedure presented is general and it does not require "ad hoc" techniques such as those proposed to solve similar problems in the frequentist settings, which are usually applicable only to particular cases. In addition, some of the examined problems have not yet been covered in the literature.

Bertolino, F. et al. A new Bayesian Discrepancy Measure. arXiv:2105.13716, 2021.

Machine learning techniques for sensor-based household activity recognition and forecasting

Marco Manolo Manca

Marco Manolo is a PhD student in the Mathematics and Computer Science Program, under the supervision of Prof. Daniele Riboni. Marco Manolo completed both his Bachelor's degree and his Master's degree in Mathematics at the University of Cagliari. His research interest is machine learning applied to smart systems. During his PhD student period, he also collaborated with the CRS4 research centre; this collaboration led to the publication of a paper (which will form part of his PhD thesis) about Non-Intrusive Load Monitoring (NILM).

In his third year, he was a visiting researcher at the *Interactive Technologies Institute (LARSyS)* at the *Instituto Tecnico* of Lisbon (Portougal). In particular, he spent six months investigating the issue of appliance recognition under the supervision of Dr. Lucas Pereira.

His PhD thesis, *Machine learning techniques for sensor-based household activity recognition and forecasting*, focuses on the machine learning application on signals from sensors installed in a house: data from position sensors, door sensors, smartphones or smart meters, and investigates the use of advanced machine learning algorithms to recognize and forecast inhabitant activities, including the use of appliances and the power consumption.

The main field of study of this thesis is the application of machine learning techniques, and in particular deep learning techniques, to

problems related to the disaggregation and forecasting of electrical signals.

Some parts of the thesis focus mainly on the NILM problem, that aims to identify the operating state (on/off) and the precise energy consumption of individual electrical loads, considering only the aggregate consumption of these loads as input.

Manca, M. M. et al. present a work that address the NILM problem.

They use a Deep Learning method to disaggregate the low-frequency energy signal generated directly by the new generation smart meters being deployed in Italy, without the need for additional specific hardware.

Namely, they apply a Deep Learning methodology based on Convolutional Neural Networks to two reference datasets, for which they filter the aggregate load signal simulating the *Chain* protocol, used in smart meters.

They apply the neural network to two datasets in which the aggregated signal is filtered to reproduce a *Chain 2* type signal and they verify the achievable performance.

The results show that with a reasonable choice of filter parameters an accurate disaggregation is achieved with a significant reduction in the volume of data transmitted, thus realizing an effectively non-intrusive consumption monitoring, feasible both on user and utility side. These results also highlight how rich in information the electrical signal of consumption can be, and emphasise the need for special attention in the protection of sensitive information that can be derived from it.

Manca, M. M. et al. Deep learning based non-Intrusive load monitoring with low resolution data from smart meters. Communications In Applied and Industrial Mathematics, 2022, 13 (1): 39-56

Sensors and AI algorithms to support frail and disabled people

Silvia Maria Massa

Silvia Maria Massa has got her BSc in 2016 and her MSc in 2019 in Computer Science at the University of Cagliari. Already in her early university years, she felt a strong interest in the application of computer science in the healthcare field. During her PhD years, she was able to cultivate this passion, under the supervision of Prof. Daniele Riboni, by working on several projects that aimed to improve the current state of available technologies to support people with disorders affecting the mind or motor system through the use of sensors coupled with signal processing methods and AI algorithms. A substantial portion of the world's population deals with disability. Many disabled people do not have equal access to health care, education, and employment opportunities, do not receive specific disability-related services, and experience exclusion from everyday life activities. One way to face these issues is through the use of healthcare technologies. Unfortunately, there is a large amount of diverse and heterogeneous disabilities, which require ad-hoc and personalized solutions. Moreover, the design and implementation of effective and efficient technologies is a complex and expensive process involving challenging issues, including usability and acceptability. The work conducted during the PhD was described in the thesis *"Sensor-based artificial intelligence to support people with cognitive and physical disorders"*. The first project carried out was focused on mental state monitoring. We investigated the application of a low-cost portable Electroencephalography sensor and supervised learning

methods to evaluate a person's attention. Indeed, the analysis of attention has several purposes, including the diagnosis and rehabilitation of children with attention deficit/hyperactivity disorder. A novel dataset was collected from volunteers during an image annotation task, and used for the experimental evaluation using different machine learning techniques. Then, in the second project, we focused on addressing limitations related to motor disability. We introduced the use of Graph Neural Networks to process High-Density Electromyography (HD-EMG) data for upper limbs amputees' movement/grasping intention recognition for enabling the use of robotic prostheses. HD-EMG sensors can simultaneously acquire EMG signals from different parts of the muscle, providing a large amount of spatio-temporal information that needs to be properly exploited to improve recognition accuracy. The investigation of the approach was conducted using a recent real-world dataset consisting of EMG signals collected from 20 volunteers while performing 65 different gestures. In the latest project, we developed a prototype of a versatile interactive system that can be useful to people with different types of disabilities. The system can maintain a food diary for frail people with nutrition problems, such as people with neurocognitive diseases or frail elderly people, which may have difficulties due to forgetfulness or physical issues. The novel architecture automatically recognizes the preparation of food at home, in a privacy-preserving and unobtrusive way, exploiting air quality data acquired from a commercial sensor, statistical features extraction, and a deep neural network. A robotic system prototype is used to simplify the interaction with the inhabitant. For this work, a large dataset of annotated sensor data acquired over a period of 8 months from different individuals in different homes was collected.

Large scale acquisition of complex environments by data fusion from mobile visual and depth sensors

Armando Arturo Sánchez Alcázar

I was born in Barcelona, Spain in 1986, and I spent most of my childhood and adult life in Valencia. I completed both my Bachelor's and Master's degrees in Industrial Engineering at the Universitat Politècnica de València, with a focus on Automatic Systems, Control, and Robotics. I completed my Master's Thesis at Sheffield Hallam University in the UK, where I worked on a project to integrate a mobile manipulator robot into the transport system of a hospital.

The project was carried out in the Department of Engineering and Mathematics and the Centre for Automation and Robotics Research during the second semester of the 2018/2019 academic year.

I joined the EVOCATION Marie Skłodowska-Curie Actions Innovative Training Network as an Early Stage Researcher and began working at GEXCEL, a private company in Brescia, Italy that specializes in geomatics, 3D mapping, and surveying, in October 2019.

At this time, I also joined UNICA's PhD program and began a research project consisting on *Large scale acquisition of complex environments by data fusion from mobile visual and depth sensors.* The project requires the development of a mobile 3D mapping system suitable for the acquisition of large environments by exploiting LiDAR, panoramic imaging and inertial sensors in a mobile setup, and the creation of reference datasets for further processing.

During this 3-year period, the most important achievement of the project is the successful development of a working prototype. The mobile mapping system can combine inputs from all the involved sensors, and is able to generate data that can be used both in industry applications and in research, as demonstrated in the work done in collaboration with CRS4 related to the densification of sparse depth data with machine learning techniques, the release of the *Indoor3DMapping* public dataset and the deployment of the prototype system itself in environments of industrial and architectural interest.

Moreover, the system is able to perform the tasks described previously overcoming the challenges related to a wearable mobile system regarding size and weight limitation, power consumption and processing power with a special focus in flexibility, since it is very desirable that developing new functionalities and supporting new hardware is as easy and fast as possible, making it attractive for people interested in building on top of our platform. Finally, robustness in the data acquisition played a central role in the design of the system, which is meant to be used by professional surveyors that need to work in environments as diverse as AEC, heavy industry, mining operations… A failure in data acquisition could potentially lead to important losses in time and resources, specially when the survey requires traveling to a remote location in difficult conditions.

Locomotion Traces Data Mining for Supporting Frail People with Cognitive Impairment

Samaneh Zolfaghari

Samaneh Zolfaghari has started her PhD in October 2019 in Mathematics and Computer Science at the Department of Mathematics and Computer Science of the University of Cagliari under the supervision of Prof. Daniele Riboni. Her research area is on sensor-based behavior and locomotion monitoring for healthcare applications.

Previously, she was a Research Collaborator and Research Fellow at Internet Technology Center, Shahid Rajaee Teacher Training University, and Computer Science Department of Alzahra University, Tehran (IRAN), respectively. She has been a visiting scholar for more than 1 year at the cognitive methods for situation-aware assistive systems (CoMSA^{2}t) research group at the Faculty of Computer Science and Electrical Engineering of the University of Rostock, Germany.

Her research interests are in information retrieval and machine learning for healthcare, mobile and pervasive systems, and automatic recognition of human activities.

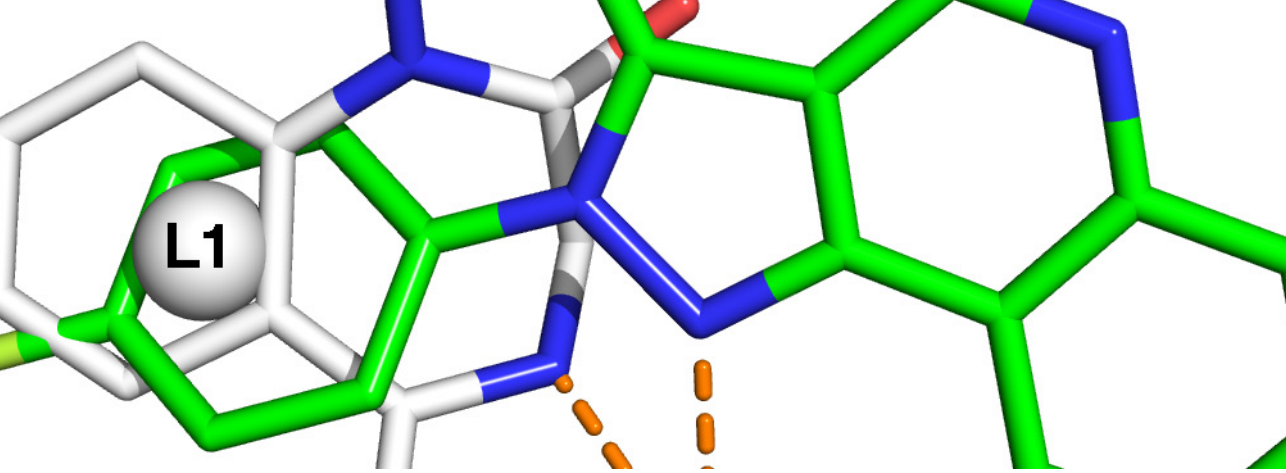
The rapid increase in the senior population is posing serious challenges to national healthcare systems. Hence, innovative tools are needed to early detect health issues, including cognitive decline. Several clinical studies show that it is possible to identify cognitive impairment based on the locomotion patterns of the elderly.

Thus, the PhD thesis entitled "*Locomotion Traces Data Mining for Supporting Frail People with Cognitive Impairment*" at first step focused

on providing a systematic literature review of locomotion data mining systems for supporting neuro-degenerative diseases (NDDs) diagnosis, identifying locomotion anomaly indicators and movement patterns for discovering low-level locomotion indicators, sensor data acquisition, and processing methods, as well as NDDs detection algorithms considering their pros and cons.

Then, we investigated the use of sensor data and deep learning to recognize abnormal movement patterns in instrumented smart homes. In order to get rid of the noise introduced by indoor constraints and activity execution, we introduced novel visual feature extraction methods for locomotion data. Our solutions rely on locomotion trace segmentation, image-based extraction of salient features from locomotion segments, and vision-based deep learning. Furthermore, we proposed a data augmentation strategy to increase the volume of collected data and generalize the solution to different smart homes with different layouts.

We carried out extensive experiments with large real-world datasets acquired in a smart-home test bed from seniors, including people with cognitive diseases. Experimental comparisons show that our system outperforms state-of-the-art methods.



PhD programme in Molecular and Translational Medicine

Coordinator: Sebastiano Banni

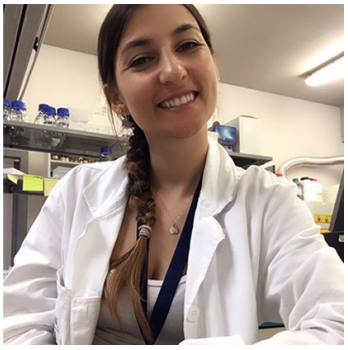
The Molecular and Translational Medicine PhD program at UNICA aims to provide students with a high-level research experience, complemented by a range of stimulating academic and training activities. Excellent mentorship is the cornerstone of the Ph.D. training. The overall goal is to empower students with the essential skills to pursue a distinguished career in biological and/or medical sciences, either in research institutions or in the biotech industry.

Molecular and Translational Medicine PhD program welcomes students from a variety of educational backgrounds.Working in a truly multidisciplinary environment, students carry out their research in one of more than 20 Faculty research laboratories headed by well-established Italian and international scientists, further favored by the recent agreement with the Universitè Laval, Quebec City, Canada.The two curricula encompass a broad spectrum of interests and research objectives with a common denominator, the translational approach to research.Molecular Oncology and Pathology: PhD Students in the molecular oncology and pathology curriculum investigate genetic/epigenetic alterations and molecular epidemiology of solid and ematologic cancers, cancer biomarkers of diagnostic and prognostic value, genes involved in the pathogenesis of rare genetic diseases, molecular mechanisms of neurodegeneration, molecular interactions of pathogens with the host. Nutritional and Metabolic Sciences: PhD Students

in the nutritional and metabolic sciences curriculum investigate, at the molecular level, the nutritional and metabolic impact of nutrients in physiological and pathophysiological conditions where the nutritional and/or metabolic component is particularly relevant. However, as you may evince from the PhD students' contribution of the 35th cycle, the research conducted within the PhD program is much broader reflecting a great dynamism and continuous evolution of the scientific interaction between students and tutors.

Study of bioactive compounds from Sardinian common bean *Phaseolus vulgaris*

Stefania Peddio



Stefania Peddio graduated cum laude in Biology MSc in 2016. She is currently completing her PhD (XXXV cycle) at Cagliari University, Biomedical Sciences Department under the supervision of Prof. Paolo Zucca. During her studies she joined the research group of Dr. Viviana Cristiglio at the Institut Laue-Langevin (Grenoble, France), studying *in silico* the protein/protein interactions through the density functional theory (DFT).

Her PhD project is entitled "Proteinaceous inhibitors of α-amylase and α-glucosidase activity from common bean (*Phaseolus vulgaris* L.): biochemical characterization and phylogenetic analysis of Sardinian cultivars". The main aim is to characterize plant proteins involved in the treatment of widespread diseases such as obesity and diabetes.

In particular the content of α-amylase and α-glucosidase proteinaceous inhibitors was analyzed in several Sardinian common bean cultivars. The inhibitor was then purified, characterized and tested for its effectiveness against mammalian and insect α-amylase.

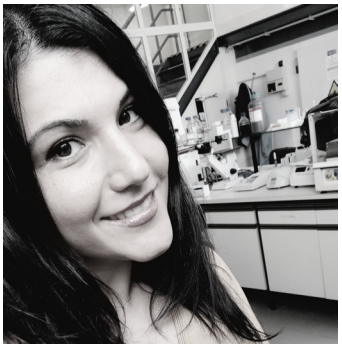
Moreover, it was investigated the inhibitor gene and partially reconstructed the primary and secondary structure of the inhibitors expressed in all cultivars.

These data could improve the knowledge about Sardinian biodiversity and could increase the commercial value of some cultivar laying the foundation for the development of new food supplements.

Peddio, et al. Common bean (*Phaseolus vulgaris* L.) α-amylase inhibitors as safe nutraceutical strategy against diabetes and obesity: An update review. Phytotherapy Research, 2022, 36(7), 2803– 2823.

Modulatory effect of olive oil phenols and their metabolites on inflammatory response in intestinal and endothelial *in vitro* models

Sonia Zodio



Sonia Zodio has a degree in Toxicology and a master's degree in Food Science and Nutrition. She has focused her training and her interest on the study of the nutraceutical properties of foods commonly consumed with the Mediterranean diet and her thesis was focused on the study of the anti-inflammatory and antioxidant properties of phenolic exctracts of table olives from Sardinian "Tonda di Cagliari" cultivar. After graduation she had the opportunity to continue working on the investigation of the properties of dietary phenolic compounds *in vitro*, through an internship at the Laboratory of Experimental Pathology of the Department of Biomedical Sciences of the University of Cagliari in 2016, supervised by prof. Monica Deiana, and through an intership at the Consejo Superior de Investigaciones Científicas (CSIC), Instituto de Parasitología y Biomédicina "López Neyra (Granada, Spain) in 2017, supervised by Dr. JuanCarlos Morales, using specific methods and tests (such as MTT assay, dichlorofluorescein test, etc.) for the evaluation of the antioxidant potential of pterostilbenes, resveratrol and derivatives in different cell cultures such as colon adenocarcinoma cells (Caco-2), neuronal cells (SH-SY5Y), inflammatory-related cells (RAW) and cancer cells (HT-29).

She joined the PhD program in Molecular and Traslational Medicine at the University of Cagliari in 2019, whose project entitled "Modulatory effect of olive oil phenols and their metabolites on LPS-induced inflammatory response in Caco-2 and on HG-induced inflammatory

response in HUVEC cells", aims to evaluate the protective effect of the main phenolic compounds of extra virgin olive oil, hydroxytyrosol, tyrosol and their sulphate and glucuronide metabolites, on the inflammatory response at intestinal and endothelial level.

It is well known that olive oil phenolics are able to prevent and/or slow down the progression of the most common degenerative diseases, where oxidative stress and inflammation play a key role, such as, Inflammatory Bowel Diseases (IBDs) and Cardiovascular Disease (CV), at the bases of which there is a loss of functionality of the intestinal and endothelial barrier, which leads to the onset and maintenance of a chronic inflammatory process.

During her PhD and during her training abroad in Barcelona, she worked on the study of the dysfunction of the epithelial and endothelial barrier, in response to pro-inflammatory and pro-oxidant stimuli, in particular LPS (bacterial endotoxins) and/or a hyperglycemia condition focusing on the alteration of tight junctions (TJ) structure and the activation of cellular pathways, as mitogen-activated protein kinases (MAPKs) and NLRP3 inflammasome, which are linked to chronic inflammatory diseases. She demonstrated how the phenolic compounds of olive oil HT and Tyr as well as their sulphate and glucuronide metabolites are capable to modulate LPS stimulation and also attenuated HG cell damage, limiting the alteration of TJ and the activation of MAPKs and NLRP3 inflammasome in Caco-2 and HUVEC cells, suggesting they could play a significant role in the maintenance of intestinal mucosa integrity and in preserving the endothelial barrier function, acting as direct antioxidants and to modulate the cellular redox state, through the interaction with the intracellular signaling pathways involved in the response to oxidative stress and in the initial stages of the inflammatory process.The methodological approaches include analytical techniques such as HPLC, LC mass spectrometry, *in vitro* assay such as permeability assay (TEER), viabillity test (MTT), molecular biology techniques such as Real-time PCR and Western blot analysis.

Serreli G., *et a*l., Ferulic Acid Metabolites Attenuate LPS-Induced Inflammatory Response in Enterocyte-like Cells, *Nutrients* 2021, 13, 3152.

PhD program in Neuroscience

Coordinator: Paola Fadda
Vice-Coordinator: Annarosa Carta

The neurosciences are a field of high scientific relevance, constantly growing for the combined application of molecular, cellular and physic technologies, aimed at investigating the complex processes of the central and peripheral nervous system.

The International PhD program in Neuroscience at UniCA involves the Department of Biomedical Sciences and the Department of Medical Sciences and Public Health. The PhD faculty includes both basic and clinical researchers from UniCA, foreign Universities and the CNR Institute of Neuroscience, Cagliari section, holding multiple skills and several collaborations with national and international research centres.

The fields of interest within the neurosciences include chemical neuroanatomy, neurophysiology, sensorial physiology, neurobiology, neuropathology, neurodegenerative mechanisms, neuropsychopharmacology, behavioral neurosciences, and the development of new diagnostic tools and new molecules acting on the nervous system. Final goal of the PhD program in Neuroscience is the traineeship of independent scientists, that will be able to manage basic and clinical research on the nervous system with a multidisciplinary approach.

The diagnosis of dystonia, an issue yet to be solved

Tommaso Ercoli

PhTommaso Ercoli graduated in Medicine in 2015 at the University of Cagliari, where in 2020 he obtained his specialty in Neurology. He is currently a PhD student in Neuroscience at the University of Cagliari, where he is also working as Research Fellow under the supervision of Prof. Giovanni Defazio. He was awarded the title Honorary Clinical Fellow from the University of Edinburgh (UK) during the time spent working at the *Centre for Clinical Brain Sciences*, under the supervision of Prof. Jon Stone and Prof. Alan Carson. The focus of his research are neurodegenerative disorders, movement disorders and functional neurological disorders. The international partnership and the national collaboration with other centers are important features of his research.

The title of the PhD thesis is *"The diagnosis of dystonia, an issue yet to be solved"* and the overall aim of the work is to help clinicians to better diagnosis idiopathic dystonia and functional dystonia. Due to the lack of validated diagnostic biomarkers, the diagnosis of dystonia is based on clinical examination and therefore may be challenging and open to bias. The factors contributing to misdiagnosis of dystonia can be summarized in two main points: i) the huge variability in the clinical phenomenology of dystonia; ii) the existence of a bunch of medical conditions mimicking the abnormal postures/movements induced by dystonia. For this purpose, the thesis is organized in two different studies.

In the first study a diagnostic algorithm was developed to reduce the risk of misclassifying functional dystonia. These findings extend the current diagnostic approach to functional dystonia by showing that clinical information about symptom onset, fixed dystonia, and history of peripheral trauma may provide key clues in the diagnosis of functional dystonia.

The second study provides practical guidance for clinicians in confirming or refuting suspected cervical dystonia, which is the most frequent type of dystonia. The proposed algorithm shows that an accurate diagnosis of cervical dystonia can be achieved if, in addition to the core motor features, we also consider some clinical features related to dystonia mimics that should be absent in dystonia.

In conclusion, this thesis sheds more light on the complex topic of the diagnosis of dystonia. Indeed, the algorithms proposed in the two studies provide a helpful tool for clinicians in their practice. The findings of the first study may help in the differential diagnosis between functional dystonia and idiopathic dystonia; and the guideline proposed in the second study will reduce variability in diagnosing cervical dystonia, which was a crucial need in the field.

Ercoli T, Defazio G, Geroin C, et al. Sudden Onset, Fixed Dystonia and Acute Peripheral Trauma as Diagnostic Clues for Functional Dystonia. Mov Disord Clin Pract. 2021; 8(7):1107-1111.

Rats 50-kHz ultrasonic vocalizations as a possible marker of the affective properties of dopamine-replacing therapy in Parkinson's disease

Jacopo Marongiu

I obtained my master's degree in Chemical and Pharmaceutical Technology in 2018, spending my thesis traineeship at University of Cagliari, Department of Biomedical Sciences. In the same year, I was also qualified as a pharmacist. In 2019, I enrolled the PhD program in Neuroscience at the University of Cagliari under the supervision of Prof. Micaela Morelli at the Department of Biomedical Sciences, Section of Neuroscience where I developed my PhD project *"50-kHz ultrasonic vocalizations in hemiparkinsonian rats repeatedly treated with dopaminomimetic drugs as a possible behavioral marker of the affective properties of dopamine-replacing therapy in Parkinson's disease"*. The prolonged use of dopamine replacement therapy (DRT) in Parkinson's disease (PD) may lead to motor and non-motor complications. The latter include alterations in the emotional state and the manifestation of iatrogenic psychiatric-like disturbances. However, the effective management of the psychiatric-like disturbances caused by the use of DRT in PD represents an unmet need, also due to a substantial lack of effective experimental models used to study the neurobiology of these disturbances. In this regard, during my PhD, we evaluated: 1) how apomorphine, L-DOPA and pramipexole (three drugs used in DRT of PD which have been associated with the manifestation of psychiatric-like disturbances) modified the emission of 50-kHz ultrasonic vocalizations (USVs), a behavioral marker of positive affect, in rats bearing a unilateral lesion with the dopaminergic neurotoxin 6-hydroxydopamine (6-OHDA) in

the medial forebrain bundle; 2) the correlation between the numbers of calls emitted and of contralateral rotational behavior performed by the lesioned rats, to disclose the effects that these drugs elicited on emotional state and motor function. The results showed that hemiparkinsonian rats repeatedly treated with apomorphine, L- DOPA, or pramipexole, three drugs that have a different dopaminomimetic profile, display dissimilar modifications in the emission of 50-kHz USVs. Thus, hemiparkinsonian rats treated with either apomorphine or L-DOPA, but not pramipexole, markedly vocalized during repeated treatment and after drug challenge, and showed conditioned calling behavior. This suggests that dopaminergic denervation may enhance the sensitivity of rats to the positive effects that apomorphine and L-DOPA elicit on the emotional state. Moreover, hemiparkinsonian rats treated with apomorphine or L-DOPA displayed sensitization and conditioned calling behavior, suggesting that the repeated exposure to drugs used in DRT persistently modifies the affective state of dopamine-denervated rats. Furthermore, although apomorphine, L-DOPA and pramipexole all stimulated contralateral rotational behavior, only hemiparkinsonian rats treated with apomorphine and L-DOPA displayed an increased number of 50-kHz USVs, indicating that calling behavior in hemiparkinsonian rats treated with dopaminomimetic drugs is not a byproduct of motor activation. Since 50-kHz USVs are considered a marker of positive affect in rats, the present results may be useful for further characterizing at the preclinical level the effects that dopaminomimetic drugs used in the DRT of PD elicit on the emotional state. In addition, I spent 7 months of my PhD program as a visiting PhD student at the University of Murcia, Spain. Under the supervision of Prof. Maria Trinidad Herrero Ezquerro, I was involved in a project aimed at evaluating the sex differences in a chronic model with the dopaminergic neurotoxin MPTP in the diurnal rodent Octodon degus.

Metabolomic characterization of Multiple Sclerosis

Federica Murgia

I graduated in Pharmaceutical Chemistry and Technology at the University of Cagliari in the 2011 under the supervision of Prof. Luigi Atzori. In that period, I joined the Metabolomics group. I completed the residency in Clinical Pathology (5 years, University of Sassari, Italy) discussing the thesis "Metabolomic study for the discovery of new biomarkers in patients with multiple sclerosis". I continued to work at the University of Cagliari as research fellow firstly and then as PhD student under the supervision of Prof. ssa Eleonora Cocco with the aim to perform metabolomic studies on a cohort of patients affected by Multiple sclerosis. My area of expertise includes the use of the analytical techniques such as Nuclear Magnetic Resonance (NMR) and Mass Spectrometry (MS) for the analysis of biological matrices (biofluids and tissue samples) and the application of multivariate and univariate statistical tools. She filed an international patent (method of the in vitro identification of drug-resistant epilepsy, WO2016/139599).

My PhD thesis titled "Metabolomic characterization of Multiple Sclerosis" is focused on the study of the Multiple sclerosis (MSc) from the metabolomics point of view with the aim to identify potential biomarkers that can represent new diagnostic marks, therapeutic targets or be helpful in explaining important pathophysiological aspects that are still unclear.

The study of the metabolome allows the simultaneous determination of metabolite concentrations in biofluids, tissues or cells in a living

organism. The metabolites represent the results of the interactions between biological processes and are affected by several factors such as disease states, drugs, nutrition, lifestyle in general.

From this perspective, I analyzed different aspects of MSc using several biofluids (cerebrospinal fluid, plasma, and serum) and different analytical platforms (NMR and MS). Firstly, I analysed samples from patients affected by different form of MSc (relapsing-remitting, RRMSc and primary progressive). Then, I focused my attention on the metabolic alterations induced by the therapy in patients affected by RRMSc monitoring the patients for two years of treatment. Finally, I dedicated my attention to the concept that various autoimmune diseases, including MSc are modulate by hormonal changes, especially the female patients. I analyzed serum samples of women affected by MSc collected before and during pregnancy and puerperium finding that the pregnancy's protective role can also be evinced from the metabolic point of view.

Each analysis evidenced a specific metabolic pattern which allowed to describe the common metabolic pathways involved in the pathogenesis of the MSc. Intriguingly, the altered metabolic pathways were those related to amino acid metabolism, in particular, tryptophan, glutamate, glycine, and aspartate, oxidative stress, and alterations in energy homeostasis.

Murgia F, Lorefice L, Poddighe S, et al. Multi-Platform Characterization of Cerebrospinal Fluid and Serum Metabolome of Patients Affected by Relapsing-Remitting and Primary Progressive Multiple Sclerosis. J Clin Med., 2020;9(3):863.

Inflammation as a shared factor in both motor and non-motor aspects of Parkinson's disease

Maria Francesca Palmas

I received my BSc degree in Biology and thereafter a MSc degree in Neuroscience from the University of Cagliari. As an undergraduate student I spent three years working on projects in the field of neurobiology/genetics, under the supervision of prof. Paolo Follesa, and I graduated with a thesis entitled "Molecular characterization of GABA-BR1 Knock-out mice: pharmacological modulation of Cyp2e1 gene expression". During my master's studies I also spent two months as a visiting student at Würzburg University – Department of Neurobiology and Genetics, where I enhanced my knowledges in confocal microscopy and immunohistochemical assays. From 2019 I enrolled in the PhD program in Neuroscience, where I joined the group of Prof. Annarosa Carta and was involved on projects aimed at unrevealing the contribution of both peripheral and central inflammation in motor and non-motor symptoms of Parkinson's disease (PD). As an integrant part of the PhD program, in 2022 I have been hosted as a visiting student at the Weizmann Institute of Science, under the supervision of Prof. Michal Schwartz (Rehovot, Israel), where I collaborated on flow cytometry-immunophenotyping studies in the field of Alzheimer's disease. Moreover, I joined the "Instituto de Investigaciones Biomédicas de Barcelona" in Spain to increase my skills on image analysis techniques.

The title of my PhD thesis is: *Neuropathological role of alpha-synuclein: major contribution of inflammation in the evolution of both motor and*

non-motor symptoms of Parkinson's disease. Neuroinflammation is nowadays considered a cardinal pathological feature of PD, in which glial cells lose their homeostatic function and acquire a pro-inflammatory profile characterized by a chronic release of pro-inflammatory mediators, likely driven by pathological interactions with toxic forms of the protein α-Synuclein. Moreover, the recognized contribution of peripheral immune responses to PD neuropathology has promoted the view of this as a systemic pathology. While the role of inflammation in the neuropathology of motor symptoms has been ascertained, its role in non-motor symptoms is still under-investigated, particularly in relation to cognitive disturbances. The increasing understanding of these pathological processes and of new pharmacological targets of clinically-approved drugs, together with the enormous cost of new drugs development, has prompted the testing of available drugs for repositioning in neurodegenerative diseases.

Based on these premises, my PhD project was aimed at targeting the central and peripheral inflammatory response in PD with the immunomodulatory drug Pomalidomide, currently used in cancer pharmacotherapy. Pomalidomide was tested for its disease-modifying properties in a translational rat model of PD. In the same PD model, I investigated the contribution of neuroinflammation in PD cognitive symptoms. These studies were performed by combining behavioral *in vivo* testing and immunochemical assays on central and peripheral tissue.

Palmas MF, Ena A, Burgaletto C, et al. Repurposing Pomalidomide as a Neuroprotective Drug: Efficacy in an Alpha-Synuclein-Based Model of Parkinson's Disease. Neurotherapeutics. 2022 Jan;19(1):305-324.

Protective effects of Nasco pomace extract-loaded nutriosomes in Parkinson's disease

Pathik Hiteshbhai Parekh

I obtained my Master's degree in Pharmacology & Toxicology from the National Institute of Pharmaceutical Education and Research (NIPER)-Ahmedabad, India in 2019. As a master's student, I joined the group of Dr. Amit Khairnar, where I studied how the impairments in the autophagy pathway contribute to protein aggregation in Parkinson's disease (PD). In 2019 I enrolled in the Ph.D. program in Neuroscience at the University of Cagliari, where I joined the research group of Prof. Micaela Morelli. In 2022, I joined the team of Prof. Vèronique Sgambato at the Institute of Cognitive sciences in Lyon, as part of my Ph.D. program, where I developed a non-human primate model of Impulse-control disorders in PD. Under the supervision of Dr. Annalisa Pinna, I am investigating the protective effects of Nasco pomace extract-loaded nutriosomes (Nasco Nutriosomes) in the mouse model of PD characterized by treatment with the neurotoxin MPTP.

My Ph.D. thesis, entitled *'Oral nano-delivery of Nasco pomace extract exerts neuroprotective and anti-inflammatory effects in the MPTP-mouse model of Parkinson's Disease'* is focused on the investigation of the protective effects of Nasco Nutriosomes towards the MPTP-induced neurodegeneration and neuroinflammation. A growing body of evidence demonstrated that oxidative stress and neuroinflammation contribute to the degeneration of nigrostriatal dopaminergic neurons, a key neuropathological hallmark of PD. Despite significant progress being made in the discovery and characterization of genetic and environ-

mental factors contributing to PD at present, there is no preventive or curative intervention. Current PD treatments are, in fact, only meant to manage the motor and non-motor symptoms.

In this context, grape pomaces, a waste by-product of wine production have recently received great attention for their richness in polyphenols, compounds known to exert anti-inflammatory and antioxidant effects. These pomaces, however, have low brain bioavailability when administered orally due to their extensive degradation in the gastrointestinal tract. To overcome this problem, Nasco pomace extract was incorporated into novel nanovesicles called "nutriosomes" and their neuroprotective and anti-inflammatory effects were evaluated in the MPTP-mouse model of PD, a model that produces a progressive and bilateral degeneration of nigro-striatal dopaminergic neurons. The findings demonstrated that Nasco pomace extract when delivered through the nutriosomes significantly prevented MPTP-induced degeneration of nigrostriatal dopaminergic neurons and activation of astrocytes and microglia, key players involved in the neuroinflammatory processes. In addition, Nasco Nutriosomes effectively attenuated the MPTP-mediated production of pro-inflammatory interleukin-1β from microglial cells both in the striatum and substantia nigra pars compacta, the brain regions which are widely affected in the PD. Overall, these results highlight the therapeutic effects of Nasco pomace extract when administered in a nutriosome formulation in the MPTP mouse model of PD and validate the effectiveness of the nutriosome preparation over suspension as an innovative nano-drug delivery system for *in vivo* administration. Our current investigation aims at the morphological analysis of astrocytes and microglia and to detect whether Nasco-Nutriosomes could also restore the MPTP-induced morphological changes in glial cells and hence provide protection against neuroinflammation.

Parekh P., *et. al.* Characterization of Nasco grape pomace-loaded nutriosomes and their neuroprotective effects in the MPTP mouse model of Parkinson's disease. Front. Pharmacol., 2022. DOI: http://dx.doi.org/10.3389/fphar.2022.935784

Cellular aging and pleiotropy in psychiatric disorders and pharmacological response

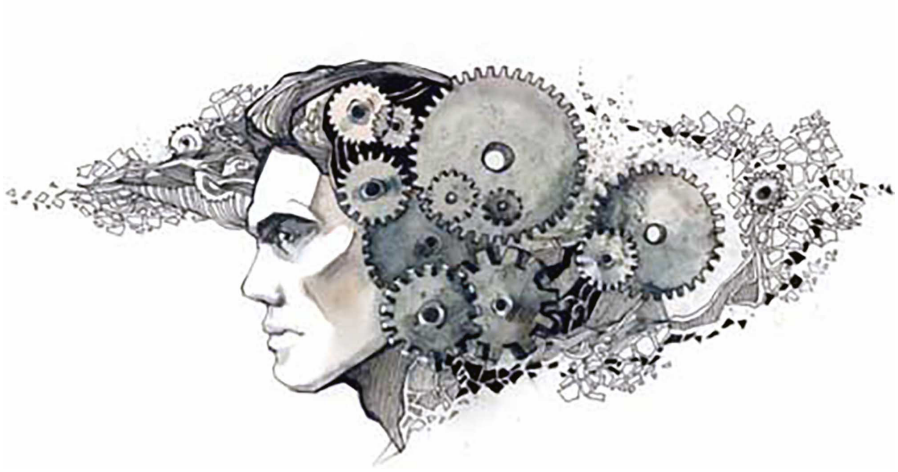
Claudia Pisanu

I obtained a degree in Medicine in 2011 and a specialization in Medical Pharmacology in 2017 at the University of Cagliari. In 2012 I joined the group of Prof. Maria Del Zompo at the Department of Biomedical Sciences of the University of Cagliari and gained experience in different experimental and computational methods to investigate molecular determinants of complex traits such as predisposition to psychiatric disorders and response to psychotropic drugs. My training included research internships at Uppsala University (Sweden) and at the National Institute of Mental Health (NIMH) in Bethesda (US). In 2017 I obtained a fellowship funded by Fondazione Umberto Veronesi and in 2018 I've started my Ph.D. in Neuroscience at the University of Cagliari, under the supervision of Prof. Alessio Squassina.

My research is aimed at developing a more comprehensive understanding of the biological underpinnings of psychiatric disorders and response to psychotropic treatments, to implement this knowledge in precision psychiatry. Precision medicine is an emerging approach that aims to provide a more tailored treatment by taking into consideration the individual demographic, clinical, lifestyle and biological characteristics. Compared with other clinical specialties, the application of precision medicine in psychiatry is still in its early phases. My Ph.D. thesis entitled "*Towards precision medicine in psychiatry: investigating the contribution of cellular aging, pleiotropy and gender differences in psychiatric disorders and pharmacological response*" reports results of four

studies in which we explored the role of different factors that might contribute to the development of precision psychiatry. The first study investigates the interplay between telomere length (the main marker of cellular aging) and levels of two inflammatory markers in patients with bipolar disorder, major depressive disorder and schizophrenia, characterized for response to pharmacological treatment. Our results suggest that patients with major depressive disorder or schizophrenia present shorter telomere length and higher inflammation, and these factors were found to be even more altered in patients with treatment-resistance compared with treatment-responsive patients. In the other three studies I applied different computational methods to identify genetic loci shared between severe psychiatric disorders and related traits (i.e. risk-taking propensity, telomere length and metabolic phenotypes). Some of the applied methods are based on pleiotropy, i.e. the association of genetic variants with more than one trait. I also integrated genome-wide association data with transcriptomic data and used different methods to explore the potential functional role of identified variants and related genes, some of which might be suitable drug targets such as the Calcium Voltage-Gated Channel Subunit Alpha1 C (CACNA1C) gene, a known target of calcium channel blockers previously suggested to be implicated in bipolar disorder. In the last study I also focused on exploring gender differences in genetic determinants shared between psychiatric disorders and metabolic phenotypes, highlighting the relevance of gender in the identification of pleiotropic loci.

Pisanu C., *et al.* Investigation of genetic loci shared between bipolar disorder and risk-taking propensity: potential implications for pharmacological interventions, *Neuropsychopharmacology*, 2021; 46 (9): 1680-1692.



PhD programme in Philosophy, Epistemology, Human Sciences

Coordinator: Giuseppe Sergioli
Vice-coordinator: Francesca Ervas

The Ph.D. program in Philosophy, Epistemology and Human Sciences is an interdisciplinary Ph.D. course, devoted to investigate general issues regarding philosophy, science and humanities. One of the peculiarities of the course is to find out common interests among different research fields and investigate them as potential resources for the advances in the general context of human knowledge.

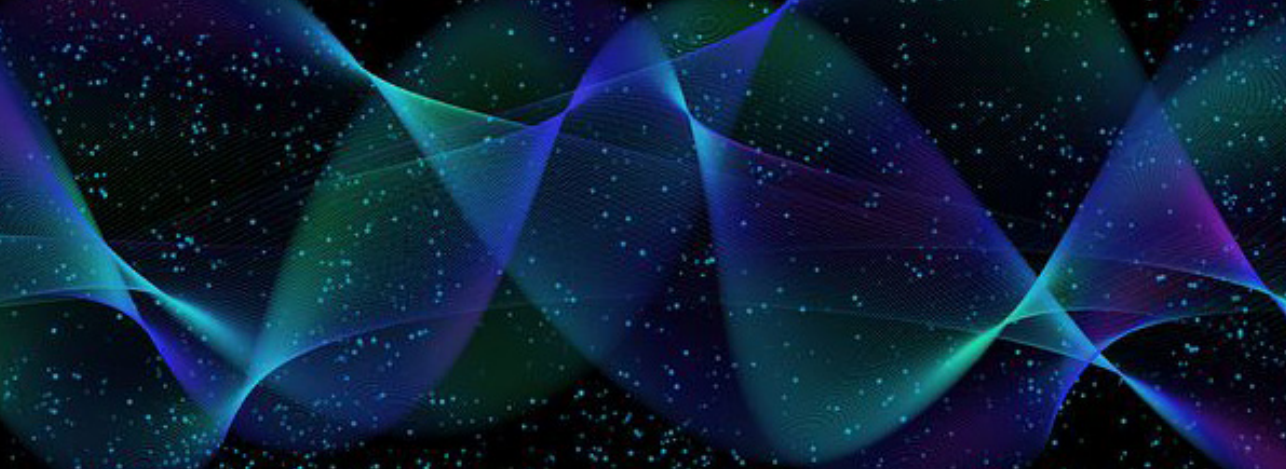
The program is divided into three research areas:

- *Philosophy and history of concepts.* This pilot mostly addresses problems and methodologies related to theoretical research, with special reference to the reasoning and thinking models that belongs to model and ancient tradition. The process of conservation and transmission of the ideas and of general knowledge is particularly considered within this pilot.
- *Logic and epistemology.* This pilot is mostly devoted to issues regarding logic, foundations of science and the formal analysis of the deductive, natural, and human sciences. Special attention is addressed to artificial intelligence, information science and communication of scientific contents.
- *Pedagogical and psychological sciences.* This pilot addresses educational themes and methodologies, even in accord with

their connections with social and psychological environment. Interest is devoted to mind theory and cognitive processes, also regarding language and inclusion of diversity in educational and community contexts.

The Pd.D. programme involves twenty Ph.D. students (no one belonging to the XXXV cicle), distributed along all the three pilots.

The Ph.D. program in Philosophy, Epistemology, Human Sciences has established partnerships with the Universidade de Lisboa and the Austral University, Institute of Philosophy, Buenos aires.



PhD programme in Physics

Coordinator: Umberto D'Alesio
Vice-coordinator: Attilio Vittorio Vargiu

The PhD School in Physics at the University of Cagliari is the only one in Sardinia: this assigns a particular role to this course for the entire Region. As for all PhD programmes, the main goal is a high-level training of our students with the peculiarity of the strong connection with national research institutes (INFN, INAF, CNR), which allows for continuous and proficuous scientific collaborations. Our PhD students are directly involved in important, national and international, experimental collaborations as well as in projects funded by international agencies. The XXXV Ciclo has seen a broad range of research activities, spanning from high-energy physics, both theory and experiment, experimental condensed-matter physics, and astrophysics. PhD students are exposed to all aspects of research. Active participation in various conferences, workshops, summer schools, collaboration meetings, as well as project drafting, allows our students to interact with senior researchers and develop skills to become independent researchers themselves. The quality of their research has been recognized also at the international level, considering the strong involvement of PhD students in highly competitive collaborations and experiments, such as those carried out at CERN (ALICE and LHCb experiments) and several radiotelescopes (including the Sardinian Radiotelescope). A second aspect of their education is the involvement in teaching-re-

lated activities. They have been committed to tutoring undergraduate students at different levels (Laurea Triennale, Laurea Magistrale) and with different backgrounds. The pandemic emergency, with its restrictions, has certainly affected the normal route of the PhD course. On the other hand, most students have successfully completed their period abroad, fully exploiting the great opportunity of strengthening their international collaborations.

The ALICE experiment: from the detector upgrade to the characterisation of the QGP

Stefano Boi

Born in Cagliari, I started to take interest in physics during the high school, when I joined the Extreme Energy Events (EEE) project, an experiment which aims to study secondary cosmic rays with an array of muon telescopes installed in Italian schools. By working with a particle detector, I decided to continue my formation in physics at the University of Cagliari, where I graduated at the first and second levels. During the first year of first level studies, I cooperated with the validation team of the Sardinia Radio Telescope and I kept working in the EEE project. My first papers are signed with the EEE Collaboration during the second level studies. In 2018, I joined the ALICE Collaboration, the experiment my PhD studies are focused on.

ALICE is one of the four big projects related to the Large Hadron Collider (LHC), a 27 km diameter accelerator installed between Switzerland and France, near Geneva. The project is mainly focused on the study of the Quark-Gluon Plasma (QGP), a state of the matter in which quarks, the constituents of the protons and neutrons, which are normally bounded together, are free to move, and behave like a fluid. This state is supposed to be reached only in high density and high energy systems, like Pb—Pb collisions. In the period between the 2018 and 2022, ALICE, together with LHC and the other experiments, faced a massive upgrade, to be able to work with an increased rate of collisions.

My work in ALICE is primarily focused on the muon spectrometer, the forward detector which tracks and measures the momentum of muons, particles similar to electrons. Before the PhD studies, I contributed to the validation tests of the prototype electronics for the muon tracking chambers (MCH). Since the beginning of my PhD, I spent several months at CERN to validate the production of the FLEX cables, a hybrid flexible PCB connection of the front-end electronics for the MCH, designed by the INFN Cagliari group, which fully supported my abroad period. I spent more than one year at CERN, including some Covid-19 lockdown periods, as expert for the upgrade of the MCH. During those periods, I worked in the installation, validation and commissioning of the upgraded MCH detector for the ALICE experiment.

With the initial plan, I was supposed to work on data analysis of the first collisions after the upgrade, to develop the new analysis software and check the quality of the upgraded experiment. Due to the Covid-19 emergency, the first collisions were delayed. I switched to another topic related to the data already acquired before the 2018 stop. The elliptic flow (v_2) describes the elliptical shape of the evolution of the hadron collision products, which depends on the initial state of the collision and the properties of a possibly produced QGP. While it was expected that only in heavy ion collisions an elliptical shape would develop, it has been shown that this happens also in small systems, such as pp and p—Pb collisions. In my studies, I have measured the v_2 in pp collisions of single muons detected in the forward rapidity region with the muon spectrometer. In case of a QGP formation, heavy flavour hadrons produced before the QGP would interact with the plasma. Some of them decay emitting a muon and can be detected with the muon spectrometer. By measuring the v_2 of the muons, we can access some of the properties of the plasma possibly produced in the collision.

Development of innovative silicon pixel sensors for high energy physics experiments

Michela Garau

During my bachelor and master thesis in Physics at University of Cagliari I have started working on the laboratory characterization of photodetectors and particle detectors for timing applications. After obtaining the master's degree in 2019, I did a three-months internship at the DESY research centre in Hamburg, within the LHC ATLAS experiment group, where I had the chance to participate to some test beam of silicon sensors and to work for the first time in a multicultural community. Thanks also to this first research experience I have decided to start a PhD in Physics, at University of Cagliari, joining the LHCb group and continuing to work on the INFN-funded TimeSPOT project.

My research activity is mainly focused on the development and characterization of innovative silicon pixel sensors for high energy physics experiments, and it is described in my PhD thesis, entitled *Development of a new silicon pixel detector with 10 ps time resolution for high luminosity future experiments*.

LHCb is one of the four main experiments of the Large Hadron Collider (LHC) located at CERN, Geneva. Each one of the LHC experiments consists in a system of several detectors designed to detect different phenomena resulting from proton-proton collisions, but also proton-lead and lead-lead collisions. These experiments are going towards a huge increase of the instantaneous luminosity (i.e., the number of collisions per cm^2 and per second) in the next ten years. This poses important challenges at a technological level for the detectors,

since simulations studies have demonstrated that a huge R&D work is needed to produce new sensors for the LHC experiments detectors. In particular, the LHCb VErtex LOcator detector, the VELO, needs to replace the current silicon sensors with innovative radiation-hard sensors providing both an excellent space resolution (10-20 μm) and an improved time resolution (30-50 ps).

The TimeSPOT project, in which I have worked during my PhD, has the purpose to develop a new detector satisfying these requirements, not only for the VELO but also for other experiments (e.g., NA62 and CMS PPS). Within TimeSPOT, innovative 3D silicon sensors optimized for timing applications have been developed.

The main activity I have done during my PhD has been the characterization of these sensors both in laboratory and in several test beam conducted at the PSI (Zurich) and at the CERN SPS (Geneva) beam test facilities. This work includes the development of the setup, the data acquisition and analysis to measure time resolution and efficiency of the TimeSPOT sensors. In particular, the characterization in laboratory has been done using a radioactive beta-source, both at room temperature and down to -40°C. These laboratory measurements, in combination with those made at the test beam, allowed to characterize both non irradiated and irradiated sensors, proving that TimeSPOT sensors satisfy present and future high-luminosity HEP experiments requirements in terms of space resolutions, time resolution and radiation hardness.

Anderlini L., *et al.*, Intrinsic time resolution of 3D-trench silicon pixels for charged particle detection, *Journal of Instrumentation*, 2020; JINST 15 P09029

Innovative silicon pixel sensors for the next upgrade of the LHCb VErtex LOcator detector

Andrea Lampis

During the master's degree in physics, obtained at the University of Cagliari, I have developed a strong interest on High Energy Physics (HEP) detector development. In this period, I had the possibility to work on Innovative particle detectors for both the CMS and the LHCb experiments of the Large Hadron Collider at CERN. Before graduating I have been selected for a two-months internship at the Silicon Detectors facility of the Fermilab in the United States.

After graduating I started my PhD within the LHCb collaboration, focusing my research on the development of silicon pixel sensors for the upgrade of the LHCb experiment.

LHCb is one of the four major experiments at the Large Hadron Collider. One of the main purposes of this experiment is to study the fundamental processes that produced, in the early Universe, the asymmetry between matter and antimatter. The study of all the fundamental processes at LHCb starts with an experimental apparatus which has the goal to reconstruct what happens after a proton-proton collision at LHC. Several particle detectors are exploited to identify, reconstruct the tracks, and measure the energy of thousands of particles produced in each collision.

In these regards, my research was focused on the development of innovative detectors capable of reconstructing the path of the charged particles and trough them to measure with micrometric accuracy the

spatial position of the primary collision point, called the primary vertex.

In the next years an upgrade of these detectors is required since the LHC will increase the number of proton-proton collision in a single bunch-crossing, which in turn will increase the statistics recorded by the experiments and thus the accuracy with which we measure the fundamental processes but also to discover new physics. The increasing number of particles to be detected leads to several technological challenges such as a higher radiation hardness of the sensors and a time resolution of tens of picoseconds.

The goal of my studies was to develop innovative silicon sensors, within the TimeSPOT project, that can be used in the future upgrade of the LHCb VELO detector. TimeSPOT is an R&D initiative funded by INFN which aims to develop innovative tracking detectors for the upgrades of HEP experiments.

My main research activities have been the characterizations of innovative sensors, called 3D trench silicon pixel sensors, by means of an accurate laser system which I have contributed to develop. Moreover, I have conducted several beam test characterizations of 3D sensors at the SPS beam test facility, located at CERN.

My work has shown the excellent time resolution of 3D sensors even after very high radiation fluences, proving that these innovative sensors fulfil all the technological requirements of the LHCb VELO upgrade. Moreover, the measurements I have performed represent a world record result in terms of timing accuracy for charged particle detection.

During the PhD course I had the opportunity to spend one year at CERN, where I have worked in strict cooperation with the LHCb VELO group on the commissioning of the current VELO detector.

Finally, I have presented the results of my research at various international conferences, for example the IEEE NSS MIC RTD in Boston.

Lampis A. et al., 10 ps timing with highly irradiated 3D trench silicon pixel sensors, accepted for publication in JINST arXiv:2209.14632

Studies of Ξ_c^+ production in pPb collisions

Roman Litvinov

Originally from Kuragino, Russia, I took interest in physics during high school. Afterwards, I've decided to continue my studies at the Novosibirsk State University and later, at the Budker Institute of Nuclear Physics. During my bachelor and master's degrees I had an opportunity to work with SND and CMD-3 collaborations. For my PhD, I applied for the program for foreign students at the University of Cagliari and joined the LHCb group.

The LHCb is one of the 4 main experiments of the Large Hadron Collider (LHC) located at CERN, Geneva. Those experiments record high energy collisions of protons or nuclei to unfold the mysteries of the Universe, whether by detecting new particles, measuring the matter/anti-matter asymmetry or characterising new states of matter.

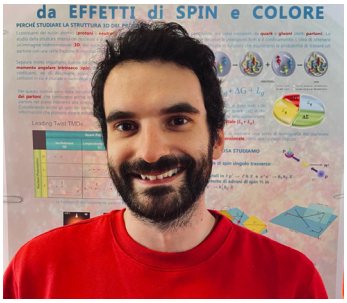
During my PhD I studied of production of the Ξ_c^+ baryon, a particle composed of *usc* quarks, in proton-lead collisions at a centre-of-mass energy 8.16 TeV with the LHCb detector. The studies are based on samples of proton-lead and lead-proton collision data, corresponding to an integrated luminosity of 12.5 and 17.4 nb^{-1}, respectively, collected by the LHCb experiment in 2016. The Ξ_c^+ events are reconstructed in the detector through the decay of the Ξ_c^+ baryon in a proton, a kaon and a pion. The analysis is performed over the transverse momentum range $2.0 < p_T < 12.0$ GeV/c in the regions of rapidity from 1.5 to 4.0 and from -5.0 to -2.5. I present the measurements of the Ξ_c^+ cross-section, production ratios of Ξ_c^+/Λ^+c and Ξ_c^+/D^0 and forward-backward asymmetry.

The results are compared to the latest theoretical predictions. These measurements can provide important information on the hadronisation of charm hadrons, as well as on the hadron structure. Since the Ξ_c^+ contains an *s* quark, the enhancement can be an indication of Quark Gluon Plasma formation.

This PhD offered me a lot of opportunities, in particular by staying several months at the CERN laboratory where I was working with the Muon group. It was a very rewarding experience to be in contact with excellent scientists from all over the world and to be as close as possible to the biggest machine mankind ever built.

J/ψ production and polarization with the inclusion of transverse momentum effects

Luca Maxia



Born in Cagliari, I completed the Bachelor's and Master's degrees at the University of Cagliari in 2017 and 2019, respectively. During this period, I developed my curiosity about theoretical particle physics. Especially, I focused my interest on the production of heavy mesons, like the J/ψ. With my Master's thesis I approached the research in this field, and, being fascinated by it, I had the opportunity to continue with the PhD.

I found extremely stimulating to use the J/ψ particle to study in detail the Quantum Chromodynamics (QCD), which is the theory used to depict the strong interactions at play when nucleons (*i.e.*, protons and neutrons) are involved. Note that, even if the is massive, this particle can be abundantly produced in every high-energy collider. Indeed, it was experimentally discovered almost 50 years ago at the Brookhaven National Laboratory and at the Standford Linear Accelerator Center. Thus, enough experimental data supports theoretical/phenomenological studies, where the J/ψ can be used to access the gluon content of nucleons.

In my research we tried to deepen our knowledge of the transverse momentum dependent (TMD) distributions of gluons inside a proton. Explicitly, we include in these distributions the possibility that partons (*i.e.* gluons or quarks) have a (small) transverse momentum component with respect to the parent proton momentum, providing a rich description of protons themselves. Indeed, we expect that the partons angular motion (which is accessible if transverse momentum

dependencies are included) significantly contributes to the total spin of protons.

Thus, we considered a physical observable that is accessible in the inclusive J/ψ production from pp collisions where one of the initial protons is (transversely) polarized. Since data are currently insufficient to impose constraints on the gluon distributions, we provided (over)estimates relative to operative and upcoming experiments by implementing numerical methods.

The correct extraction of this information, however, requires a correct theoretical description of the J/ψ production. Thus, we proposed a novel theoretical framework that includes a new quantity: the TMD shape function, which allows the exchange of transverse momentum during the J/ψ hadronization. Moreover, we suggested a simple but effective way to obtain the perturbative tail of these objects, applying it to the semi-inclusive deep inelastic scattering (SIDIS). In this process a proton and an electron interact via the emission of a virtual photon, that breaks the proton, whilst in the final state a J/ψ is measured, together with the electron. During my research work I extended this method to the case of polarized J/ψ production in SIDIS. Despite the challenges, we also improved this procedure, providing newer, more reliable TMD shape functions expressions.

All these results are widely discussed in my thesis entitled "*J/ψ production and polarization with the inclusion of transverse momentum effects*".

During my PhD, I had the pleasure of participating and the opportunity to present talks at several high-profile international conferences.

I also attended a PhD school at the JLab that helped me strengthening my general knowledge in particle physics.

Finally, thanks to the PhD program, I was able to establish a scientific collaboration with the group in Groningen (Netherlands). This 6-month experience has been enriching from a scientific/career perspective as well as for personal growth.

Study for the scientific development of the Sardinia Radio Telescope/SDSA configured for solar observations and radio-science aimed at Space Weather and Fundamental Physics applications

Sara Mulas

My studies took place at the Physics department of Università di Cagliari where I attained both my bachelor degree and my Master degree. My education and training was focused on radio-astronomy and the investigation of galactic sources. This path was enriched by an internship experience (Erasmus Traineeship) at the Max-Planck-Institut für Radioastronomie in Bonn (Germany). For my thesis work I focused on Supernova Remnants in the radio band using data acquired through the Sardinia Radio Telescope (SRT) and Effelsberg (Germany). During my PhD I deepened my studies in the field and applied the acquired knowledge to Solar physics, which has become the focus of my research. For these studies I took part in the SUNDISH project, which regularly monitors and analises the Sun in the radio frequencies to investigate the many mysteries still surrounding our star. Within the SUNDISH group I have dedicated part of my work to Space Weather studies, investigating the variations of the interplanetary environment between Earth and the Sun. In this context we are carrying out studies to correlate the evolution of the Active Regions (brilliant structures that form on the solar disk) to explosive and energetic phenomena, called Flares, of particular interest as they are linked to geomagnetic storms. The storms can generate disturbances in our technologies, such as interference to GPS networks, major damage to city electrical grids, blackouts in extensive urban areas. Through our studies we are trying to find possible precursor factors to the Flares, in order to be

able to predict important geomagnetic storms in advance. I am co-author of the scientific paper Pellizzoni A. et al., *Solar Observations with Single-Dish INAF Radio Telescopes: Continuum Imaging in the 18 – 26 GHz Range, Solar Physics, 297 :86, 2022*, which contains the preliminary results of various studies correlated to Solar Physics. We observed the Sun through the radio telescopes SRT (San Basilio) and Medicina (Bologna), acquiring more than 300 solar radio maps. They are available on our website, with extensive details of the entire project. During my PhD I also took part in the study of a new SRT configuration called Sardinia Deep Space Antenna (SDSA), thanks to a research grant launched by the Università di Cagliari, with funds from the Italian Space Agency. I investigated the Sun in the radio domain at different bands compared to SUNDISH, finding links between the two projects that could be the basis for future works. My thesis *Study for the scientific development of the Sardinia Radio Telescope/SDSA configured for solar observations and radio-science aimed at Space Weather and Fundamental Physics applications* includes the studies and the results obtained both through the SUNDISH project and the SDSA configuration. During my PhD I had the opportunity to present my work at various conferences both in Italy and abroad.

Experimental and computational investigation of fluorescent N-doped Carbon Dots

Chiara Olla

Chiara Olla started her Ph.D. in Physics in 2019 under the supervision of Prof. Carlo Maria Carbonaro. She joined her current research group as a trainee for the master's thesis where she employed advanced optical spectroscopies for the study of luminescent-magnetic materials. This work also included magnetic measurements performed in the research group of Prof. José Ángel De Toro Sánchez at the University of Castilla-La Mancha (Ciudad Real, Spain) during her three-month Erasmus traineeship.

Her Ph.D. project focuses on the all-around characterization of a new class of luminescent nanomaterials known as Carbon Dots (CDs). The rising demand for more environmental-friendly and cost-effective fluorophores in optoelectronics and photonics pushed the research on alternatives free of semiconductor elements or rare-earth-based materials. A promising green and low-cost alternative is currently represented by these fluorescent carbon-based nanoparticles that generally display low toxicity and excellent biocompatibility. But their most important feature is their efficient fluorescence in the visible region that in most cases varies with the excitation wavelength. This phenomenon is quite unusual and can be explained by assuming to have multiple emitting centers. Indeed, their structure is usually depicted as an ordered carbon core decorated with different functional groups and molecular moieties according to the synthetic and post-synthetic processes.

All these features call for the development of new optoelectronic devices which is the goal of the CANDL^2 project, standing for "CArbon NanoDots for Light-emitting materials and Lasing applications". This project, funded by MIUR within a PRIN call, aims to fill the gap of knowledge in this material properties to design CD-based lighting and lasing technology.

Since the beginning of her Ph.D., Chiara has been fully involved in the CANDL^2 project, especially in the investigation of the correlation between structure and optical features in nitrogen-doped CDs via a combined computational and experimental approach. Indeed, Chiara studies computational methods that allow modeling different N-doped structures for mimicking the experimental optical findings. At the same time, she employs different spectroscopic techniques, especially Raman spectroscopy and Time-Resolved Photoluminescence to characterize both structural and optical properties. Moreover, she deepened solid and liquid state Nuclear Magnetic Resonance spectroscopy as a 6-month visiting Ph.D. student at the University of Namur (Namur, Belgium) under the supervision of Dr. Luca Fusaro.

Her most important work dealt with the interaction of N-doped CDs with silica matrices, showing that the emissive contributions of CDs can be tuned either with the synthesis performed directly in silica that favors the formation of green-emitting N species or irradiating the samples in different environments that allowed the observation of surface centers in silica and molecular ones in water.

Olla C. *et al.* Selecting molecular or surface centers in Carbon Dots-silica hybrids to tune the optical emission: a photo-physics study down to the atomistic level. Journal of Colloid and Interface Science, 2022; 634: 402-417.

Degradation studies on different pigments: new approaches to diagnostics in Cultural Heritage

Francesca Assunta Pisu

Born in Cagliari in 1994, I graduated in Physics in 2019 at the University of Cagliari. In the same year I started my Ph.D. in Physics at the University of Cagliari working in the optical spectroscopy research group (Treetop) under the supervision of Prof. Daniele Chiriu and Prof. Carlo Maria Carbonaro. In 2021, I worked at the Foundation of Research and Technology of Hellas, in Crete, under the supervision of Dr. George J. Tserevelakis, afterward, for three months in the painting laboratory at the Royal Institute of Cultural Heritage (Bruxelles) supervised by Professor Steven Saverwyn.

My Ph.D. research work focuses on the study of the degradation processes of certain famous pigments using non-destructive and non-invasive techniques with the ultimate aim of modelling the degradation process and on developing new approaches to diagnostics.

The degradation study was directed at pigments and binders widely used in history such as cinnabar (typically employed in Roman frescoes), cadmium yellow (findable in the most famous Impressionist paints), and calcium hydroxide (binder of frescoes) to establish for each of these pigments: which final degradation products are obtained, which is the degradation path followed under the action of external agents (light, temperature, and impurities) and estimate, when it is possible, the kinetics of the degradation. Thanks to the knowledge of the kinetics of alteration, we can elaborate degradation/dating models for a particular pigment or painting technique. To respect the unique-

ness of an artwork, the use of non-destructive, non-invasive, and portable techniques is highly desirable for the realization of these kinetic models and for degradation studies. This can be achieved with the use of spectroscopic techniques such as Raman spectroscopy, Fluorescence, Luminescence, and Reflectivity. Using these techniques, it is possible to have in-depth knowledge of the chemical and electronic structure of the pigment under examination and its degradation compounds obtained as a result of the artificial aging processes. From the knowledge of the phase-conversions / element-formation duration, we can study the kinetics of degradation and be able to formulate a mathematical law to describe the chemical-physical alteration process. By reporting the degradation kinetics obtained in the laboratory with artificial aging processes on a real-time scale, a dating model can be obtained.

This model is useful to date the works containing that pigment and to judge their conservation state. Sometimes, it is also possible to obtain information on the history of the pigments.

In recent years I have developed a dating model based on the carbonation process of calcium hydroxide, the typical binder of fresco paintings. Using experimental archaeology, it is possible to simulate the carbonation of the painted surface and monitor its reaction with atmospheric CO_2 as a function of time and depth to create a carbonation/dating model for the frescoes.

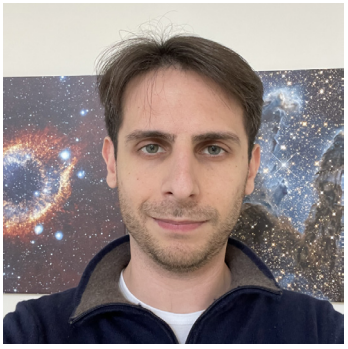
The model realized permits frescoes to be dated directly *in situ* and in a non-invasive way. It was tested on real samples and the discrepancy from the model can be traced back to peculiar sample storage conditions.

In addition, a new stratigraphic tool for frescoes based on non-conventional techniques such as photoacoustic imaging and the Spatially offset Raman spectroscopy was realized, obtaining promising results on the reconstruction of stratigraphic profiles on real samples.

Pisu F. A. *et al.* Fresco Paintings: Development of an Aging Model from 1064 nm Excited Raman Spectra. Crystals. (2021). 11(3):257.

Looking for the right storm

Matteo Trudu



Matteo obtained both his Bachelor's and Master's Degree in Physics from the University of Cagliari. His primary interests during the years spent as a student were towards theoretical aspects of Gravity: for his Master thesis he worked on the dynamics of galaxies within a modified gravity scenario. After his graduation, he won a one-year research scholarship at the Astronomical Observatory of Cagliari, where he analysed and applied non-standard techniques to remove the noise from the data recorded by radio telescopes. In the context of this project, he spent about three months at the International Centre for Radio Astronomy Research in Perth, Australia. After the scholarship, he won a PhD position at the University of Cagliari and he continued his path in the radio astronomy field. His PhD project, supervised by Prof. Andrea Possenti and Dr. Maura Pilia, with title "*Search and multi-frequency follow-up studies of radio transients: novel approaches and large campaigns*", has the aim to improve the all-round comprehension of the mysterious phenomenon of the Fast Radio Bursts (FRBs). FRBs are elusive radio flashes which last milliseconds, coming from outside our Galaxy. To date FRBs have been observed only in the radio frequencies and their origin has not been assessed yet. A striking event, which happened on the 28th of April 2020, challenged the idea of FRBs being solely extra-galactic signals. Indeed, the Galactic magnetar (a star made mostly by neutrons with an extremely intense magnetic field) SGR J1935+2154, emitted two radio bursts closely resembling the ones produced by

FRBs, with simultaneous detection by high-energy telescope satellites. This unprecedented result places magnetars as the most plausible FRB emitters and strongly motivates panchromatic campaigns toward known FRB sources in order to find, as in the case of SGR J1935+2154, their high-energy and possibly optical counterparts. A multi-wavelength campaign needs to be led by radio telescopes since radio detections are crucial both to detect the bursts and to discriminate between models which predict simultaneous multi-wavelength emissions or pre/post burst emission at higher frequencies. Matteo's PhD work had many facets. Amongst them: the development of algorithms aiming to maximise the detection of FRBs events, the ramp-up of dedicated FRB facilities, such as the refurbishment of the Northern Cross Telescope in Bologna (Italy), the coordination of a multi-wavelength campaign on a FRB. In fact, he led the radio observations of a year-long campaign on FRB 20180916B, which involved the radio facilities SRT (Italy) and the upgraded uGMRT (India) in tandem with several optical telescopes: the Asiago telescopes, CMO SAI MSU, CAHA, RTT-150 and the TNG and high-energy telescopes on board the AGILE, HXMT, INTEGRAL and Swift satellites. His work produced the detection of twenty-one new bursts from the source and provided the deepest upper limit (that is, a constraint on the energy emission at other wavelengths) in the optical band.

PhD programme in Economics and Business

Coordinator: Vittorio Pelligra

Our *PhD Program in Economics and Business* (*Dottorato in Scienze Economiche e Aziendali*) is an initiative of the Department of Economics and Business (DSEA) of the University of Cagliari. The PhD program has agreements to provide co-tutorship and joint degrees with the Universitat Jaume I, in Castelló de la Plana (Spain) and with the International University Institute "Sophia" which, despite being and international institution, is based in Florence.

The PhD program in Economics and Business offers to curious, determinate and passionate students the opportunity to gain a deeper understanding of the principles that regulate the functioning of the economic systems, the behavior of its agents, individuals, firms and institutions. It represents a unique opportunity to learn the advanced tools and techniques of economic and behavioral sciences, to go deeper into the functioning of the market, other social institutions and the firm and to develop a profound comprehension of how they are created, designed and managed. The PhD program organized in three different tracks:

1) Economics (economic theory, applied economics, economic geography, tourism economics, behavioral and experimental economics, public economics)

2) Business and Management (corporate governance, accounting systems, public management, performance measurement and management, financial and tax accounting, business analytics, marketing,

entrepreneurship, innovation management and organization, tourism studies, banking and finance)

3) Quantitative Methods (mathematical economics, dynamical systems, statistics, machine learning, A.I., computational finance; big data, econometrics, spatial econometrics, time series)

Our students form a multicultural, inclusive, and lively community of young scholars. At the end of the XXXIV cycle, six of them will present their results to the reviewer and the to the panel that will examine them and, hopefully, will award the degree of *Philosophy Doctor*

- Virginia Angius (*Business and Management*) wrote a thesis titled "Beyond the expectations: a citizens-oriented approach towards local shared services performance assessment";
- Viviana Ecca (*Business and Management*) focused on a series of "Essays on Peer Effects in Financial Misreporting";
- Rabia Fatima (*Business and Management*) investigated "How sustainable finance is becoming mainstream?";
- Oumaima Lahmar (*Economics*) focused on the role of narratives in economics and finance in a thesis titled "Making sense in the financial discourse: If finance is everywhere, is it also for everyone?";
- Matteo Opizzi (*Business and Management*) focused on "Studying PhD students as a PhD student: how do they decide to become entrepreneurs?";
- Gianluca Pusceddu (*Quantitative Methods*) presents a thesis titled "Business strategies in time of crisis: latest developments and trends";
- Silvio Tunis (*Economics*) investigated the relationship between "Preferences, immiserizing growth and structural change: a quantitative evaluation".

We wish to them all a shining career and a great future.

Beyond the expectations: a citizens-oriented approach towards local shared services performance assessment

Virginia Angius

I hold a mixed academic background in both humanities and management, with a BA in the field of cultural studies obtained from the University of Bologna and a master's degree in management of cultural heritage received at Bocconi University. I first became interested in Public Management during my MSc, where I took courses on public policy and governance. I was drawn to the field because of its focus on improving the lives of citizens and addressing social issues, and I saw the potential for my mixed background to be used to tackle these challenges.

My interest in academic research started with my master's thesis on the use of culture as a tool for integration policies. After a few years working in the fields of art and heritage in Milan and London, I returned to Sardinia to continue my academic career in Public Management.

My current research interests lie at the intersection of local government, public service delivery, and inter-municipal cooperation. I am passionate about using my research to inform policy and practice and hope to contribute to a better understanding of the factors that influence the performance of inter-municipal cooperation.

During my PhD, I have had the opportunity to work with some of the leading scholars in the field of public management, in particular during a seven-month visiting period at the Erasmus School of Social

and Behavioural Sciences in Rotterdam, and I have presented my findings at conferences both nationally and internationally.

Specifically, my dissertation features an inductive study that focuses on the assessment of the performance of local services in the case of inter-municipal cooperation, a crucial and understudied area that has the potential to inform policy and practice.

My research aims to understand how these policies are evaluated and to identify the factors that contribute to the success (or failure) of inter-municipal cooperation.

As I delved into my research, I used qualitative methods to explore how performance is measured and evaluated in the context of inter-municipal cooperation. I have also examined the perception of stakeholders in the assessment process and how different factors, such as political and financial considerations, can influence how they assess performance and the level of citizen engagement. Through a series of interviews with researchers and practitioners, I found that the assessment of performance in inter-municipal cooperation, although usually focused on financial aspects, is complex and multifaceted and requires a nuanced approach that takes into account the specific context and culture of the participating municipalities. The results of my study indicate that there is consensus among researchers and practitioners on the need for more qualitative, participatory approaches which start from the evaluation of citizen satisfaction, which is often deemed important but not as often analysed.

The findings of this study have implications for both researchers and practitioners working in the field of inter-municipal cooperation, as they highlight the need for more collaborative and inclusive evaluation approaches that consider the diverse perspectives and needs of all stakeholders involved. This study contributes to the growing body of knowledge on the evaluation of inter-municipal cooperation and has the potential to inform future research and practice in this area, by eventually providing a research agenda and propositions for future inquiry in the field.

Essays on Peer Effects in Financial Misreporting

Viviana Ecca

Viviana Ecca is a Ph.D. student in Economics and Business at the University of Cagliari. She obtained a bachelor's degree (cum laude) in Business and Economics and a master's degree in Managerial Economics (cum laude), both at the University of Cagliari. Afterwards, she applied for the doctoral program and ranked first in the selection process, winning a Ph.D. scholarship funded by P.O.R. F.S.E. 2014-2020. During the Ph.D. course, she pursued her research project on peer effects in accounting choices, and she carried out supplementary teaching activities for undergraduate courses in accounting. Moreover, she presented her works at several international and national academic conferences. She also had the opportunity to join Durham University Business School as a visiting Ph.D. student.

Her doctoral thesis *Essays on Peer Effects in Financial Misreporting* examines peers' influence in corporate misreporting decisions. Precisely, it investigates whether companies' earnings management choices are influenced by corresponding peer companies' choices. Such peer effects are especially important because they have the potential to determine social multipliers. That is, the action undertaken by firm *i* affects the reference group, which then affect back firm *i*, and so on. This implies that, due to social interactions, all the negative effects that usually result from financial misbehaviour, which affect firms and external parties, are further amplified and reinforced.

In the first part of the thesis, peer effects in real earnings management are examined among listed companies. Framing the decision to follow peers' choices as the result of a cost-benefit analysis, the study reveals the presence of causal peer effects in real misreporting. In other words, firms use real manipulation to respond to peers' real manipulation. However, additional analyses suggest that this misreporting result can be mitigated by imposing higher expected manipulation costs on firms, thus highlighting the need for external monitoring. Next, the thesis investigates peer effects' presence in a private setting, where different reporting incentives shape companies' earnings management choices. Consistent with peer effects, results show that real earnings management strategies adopted by peer firms induce firm real earnings management. The effect shapes both income-increasing and income-decreasing strategies. Interestingly, regardless of the misreporting direction, peer pressure is reinforced when firm-specific incentives make conforming with peers' choices particularly worthwhile, hence indicating how companies' choices strongly encourage their peers' misreporting actions. Finally, the role of peers in income smoothing is analyzed. Examining a setting in which smoothing is a generally accepted and sometimes desired practice, the research shows that peers can become the main determinant of the dangerous spread of misreporting actions among companies (Mura & Ecca, 2022).

Mura A., Ecca V. L'impatto dell'effetto imitativo sulle politiche di bilancio. Rivista Italiana di Ragioneria e di Economia Aziendale, forthcoming.

How sustainable finance is becoming mainstream?

Rabia Fatima

In 2015, I graduated from the MBA program at the University of Peshawar, Pakistan, where I was declared the second-best graduate of the Institute of Management Sciences (IMS) for the a.y. 2014-2015. After graduation, I served as a lecturer for more than 4 years at Iqra National University (INU), Pakistan. In 2019, I joined the PhD program in Economics and Business Sciences at the Department of Economics and Business Management, University of Cagliari, Italy.

My research interest centers around the sustainable finance research field. After completing the coursework during the PhD first year, I worked on various research projects related to social and sustainable finance, impact investing, and social impact bonds. My dissertation title is "How sustainable finance is becoming mainstream?", which is based on three main research projects. The first research project provides comprehensive knowledge regarding the intellectual structure of the sustainable finance research field, which clarifies the difference, similarities, and linkage between potential practices, financial tools, and instruments and more importantly, identifies various significant research gaps within this emerging field of finance. Considering those gaps, the second research project explores the contribution of FinTech companies in achieving sustainable development goals (SDGs). The findings of this research are twofold and highlight some significant implications for both theory and practice. First, by investigating the business models' core elements of selected FinTechs, identify direct

or/and indirect contributions of these companies to various SDGs and, based on the analysis, the research study derived eight propositions. Second, this study proposed a new Impact FinTech model, that primarily focuses on creating social and environmental values in developing as well as developed countries, which ultimately contributes to SDGs' achievement. While the third research project explicates what new developments are needed in evolving social impact bonds (SIBs) research field within the (social) finance paradigm. The overall finding of this project points out some important facts regarding the literature on SIBs from a finance perspective and proposed 37 finance-oriented research questions for future studies.

During my Ph.D., I also got the opportunity to work on two other research projects. The first research project explored how equity crowdfunding supports social enterprises to bridge their well-known funding gap issues and to generate positive social or/and environmental impacts. While the second project investigates the interplay between central banks' activities and climate risks.

Fatima, R., Boitan, I. A., & Carè, R. How Many Shades Are There in Sustainable Finance?: A Bibliometric Review. In: I. Y. Gok (Ed.). *Handbook of Research on Global Aspects of Sustainable Finance in Times of Crises*. IGI Global; 2022. 1-26. https://doi.org/10.4018/978-1-7998-8501-6.ch001

Making sense in the financial discourse: If finance is everywhere, is it also for everyone?

Oumaima Lahmar

I am Oumaima Lahmar, I come from Tunisia, and I live in Italy. I have a bachelor's in business administration (BBA) from Tunis Business School majoring in International Political Economy and Finance. After graduating in 2017, I won a scholarship granted by FORMED program to pursue my master's degree in International Management at the University of Cagliari where I developed an interest in corporate finance. I graduated two years after with Cum Laude and started my Ph.D. parcourse in 2019 with a scholarship provided by the University of Cagliari. My research field is in the Economy of Financial Intermediaries and Corporate Finance.

In the first year of my Ph.D., I had the opportunity to develop my research skills in quantitative, qualitative, and experimental methods which were further enriched during my exchange period abroad at Warwick Business School (UK), where I worked on programming and machine learning techniques.

Given that I am specializing in textual analysis applied to finance-related texts, I started my research on narrative theories inspired by philosophy, anthropology, sociology, neurology, and psychology research advancements in their investigation of the influence of narratives on the human decision-making process. It was my starting point to deepen my research on finance-related texts and specifically on the academic narrative working on my thesis entitled "Making sense in the financial discourse: If finance is everywhere, is it also for everyone?".

It seemed important to understand the impact of finance research articles on market practitioners' behavior and the dynamics between academia and financial markets. Before testing these interactions, it was necessary to examine the nature and the anatomy of the academic narrative. In fact, the second part of my PhD thesis consists of a study on the readability of the scientific literature in finance. Readability indexes are an estimation of the number of years required by the audience to understand a text. Surprisingly, the difficulty of the scientific research in finance has been increasing overtime. Readers are required to have at least 19 years of education to be able to understand an academic text which seems to be difficult to reach having market participants that sometimes are with limited financial literacy.

The third part of my thesis is a step ahead in scrutinizing the nature and the content of research articles in finance. By applying topic modeling, which is a machine learning technique, I try to identify the major debates in finance and compare these topics with the JEL classification system. This methodology proved to be reliable in analyzing word patterns and extracting the dominant themes of research. Furthermore, tracking the evolution of the debate in finance research, suggests that some topics are attracting more attention and their proportion in the corpus has been growing in the last two decades. Other themes of research show a stagnant proportion which could be a sign of a continuous interest. On the other hand, some themes are losing the scholars' interest by showing a decreasing trend in terms of interest measured by their proportion in the corpus.

To sum it up, studying scientific literature revealed a number of insightful findings that may be with great significance not only to scholars in the field but also for those who are interested in fulfilling the universities' third mission.

Studying PhD students as a PhD student: how do they decide to become entrepreneurs?

Matteo Opizzi

My name is Matteo Opizzi. I was born in Cagliari in 1993, and I have always lived in this wonderful place, with the only exception of a period of my PhD that I spent abroad. I got my master's degree in Management at UniCa, with a thesis that aimed to investigate the cognitive prototypes at the base of the identification of entrepreneurial opportunities in technology entrepreneurs. Looking back at that period of my life, I can say with certainty that was the exact moment I fell in love with entrepreneurship and its great potential for making the world a better place. Then, I decided to apply for the PhD, driven by my fascination for the idea to study further entrepreneurial dynamics. Again, that was the moment in which I fell in love with doing research and having the opportunity to give my own small contribution to the advancement of scientific knowledge. My doctoral journey has been an endless exploration of entrepreneurship as a research field. Started with a great fear of delving into a field of research characterized by a very broad and vibrant conceptual and empirical debate, and it ended with the desire to continue doing it again and again.

As often happens, I spent the first period of my doctorate immersed in reading an overwhelming amount of articles. I confess: I was not particularly enthusiastic at first, but now I acknowledge that all that work has been insightful for me to be able to add a brick to the field by standing 'on the shoulders of giants'. Then, I discovered the topic of academic entrepreneurship, that is the creation of new ventures to

valorize research results or specific competencies created within the university, and I decided to dedicate my PhD to studying that phenomenon. I liked the idea that entrepreneurship might become a tool to transform knowledge into social and economic impact. I started to work on that topic, and my first effort aimed at understanding which factors lead scientists or students to become academic entrepreneurs. In uncovering that both individual-related and university context-related factors play a role in the process of academic entrepreneurship, I continued my research by focusing my attention on a particular target group of academic actors: doctoral students, and I realized that doctoral students have enormous entrepreneurial potential because of a number of reasons. First of all, it is a fact that doctoral degree is acquiring a new role in the knowledge society, and it is no longer viewed solely as a necessary stepping stone for a future academic career. Moreover, the deep knowledge of their research topic and the skills developed along the doctoral journey make doctoral students promising innovators. In recognizing this, my empirical research focused on the need to understand how doctoral students decide to become entrepreneurs. The findings made it clear that the combination of doctoral students' prior experience and background affect the early stages of doctoral students' decision to become entrepreneurs. On the other hand, the support provided by universities for entrepreneurship appeared to be marginal at this early stage of the process. Conversely, a substantial desire to create a social impact with their research emerges as an inner drive for doctoral students' transition to entrepreneurship.

Throughout my doctoral journey, I had the opportunity to engage in numerous international collaborations. Moreover, my works have been presented at several international conferences, such as The Academy of Management Annual Meeting 2022, Rent and 3E Conference.

Business strategies in time of crisis: latest developments and trends

Gianluca Pusceddu

I graduated from the University of Cagliari with honors in International Management, attending the Frankfurt University of Applied Sciences and the Vienna University of Economics and Business (WU) as an exchange student. I also interned at a marketing firm in Liverpool and the Italian Chamber of Commerce in Zurich, exploiting the mobility programs offered by our University to build on my career while improving foreign languages and gaining self-confidence and independence. As a Ph.D. candidate, my research interests focus on business strategies and crisis management.

In particular, in my first paper, I focused on the study of a Systematic Literature Review linked to business strategies and small and medium-sized enterprises during the different phases of the crisis (prevention, response, recovery). This work was presented during the Sinergie-SIMA 2021 conference and the 81st Annual Meeting of the Academy of Management. During the Sinergie-Sima 2021 conference, the work was awarded Best Paper with publication in the Italian Journal of Management.

In the second paper, referring back to the suggestion for future research of the first study, that is, testing and validating the proposed "circular" framework, I started my 9-months research in Norway. The visiting period at BI - Norwegian Business School had my involvement in research on strategy as practice and value co-creation. The research question in this project is linked to the resilience strategies of

companies in a period of crisis, with a focus on the AEC (Architectural Engineering and Construction) industry (studying the "case" of Norwegian firms in the civil/industrial construction sector). This industry has incredibly prospered during the pandemic crisis. What I investigated was why and what strategies it has implemented. To do this, data and interviews were collected in collaboration with the BI Centre for the Construction Industry.

The third paper is related to Phygital Customer Experience. Thus, I immersed myself in a new and stimulating learning path made of augmented reality, virtual reality, and many other constantly evolving aspects (showrooming, webrooming, click & collect, etc.). The main challenge was analyzing coherent and adequate literature and identifying with a "tech-addicted researcher". A certain reluctance emerged to tackle the subject for what it is: an unprecedented (and probably no return) digital transformation. For this topic, I carried out a single case study in the first phygital store in Europe, in Milan: the Webidoo Store. I studied how consumers perceive this experience, interviewing them and differentiating their perceptions between ordinary and extraordinary experiences. This paper also extended the focus to analyze the managerial point of view to understand how firms seek to affect the stimuli to which customers respond in a phygital context by adopting flexible and agile strategies. This paper was presented for the Fourth Digital Transformation Conference earning the Best Proposal Award. Furthermore, this work has been selected for presentation during the New Business Models 2022 conference, the Sinergie-SIMA 2022 conference, and the 82nd Annual Meeting of the Academy of Management. This work is under review for publication in the Management Decision special issue entitled "A strategic perspective on flexibility, agility, and adaptability in the digital era".

Preferences, immiserizing growth and structural change: a quantitative evaluation

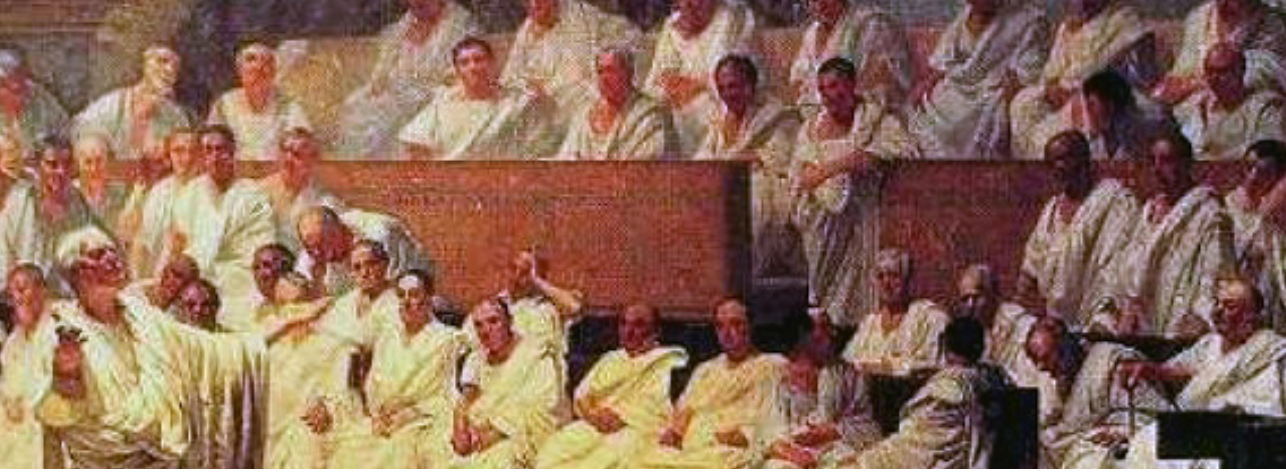
Silvio Tunis

After graduating in Economics and Business at the University of Cagliari, I enrolled in the master's degree in Economics, Finance and Public Policy. Studying theoretical models, using different software (Matlab, R, Stata) and developing and presenting projects in English allowed me to acquire essential skills for the business and academic sectors. Intrigued by the most profound economic mechanisms, I decided to explore the research world by enrolling in the PhD programme in Economics and Business (UniCa). During this adventure, I spent the first part of 2022 at the University of Kent, Canterbury, UK. This extraordinary experience has provided me with meaningful research feedback and catching up with the latest research lines in macroeconomics.

The PhD thesis I worked on during these three years is entitled *"Preferences, immiserizing growth and structural change: a quantitative evaluation"*. The expression structural change refers to the reallocation of economic activities between the agriculture, manufacturing, and service sectors. Besides being one of the mechanisms of sectoral reallocation, the interaction between consumer preferences and technological change can lead to a situation called immiserizing growth (IG). In this scenario, and within a skill-biased technical change (SBTC) framework, a sub-group of agents is not able to benefit from increases in technology production and faces a deterioration in terms of consumption, real wages, and utility function.

Intrigued by the peculiarity of the phenomenon, and considering the possible correlations between structural change, SBTC and IG, I begin my research with an extensive literature review to identify the current state of the art. Then, to theoretically and quantitatively study IG, I develop in a closed economy framework a general equilibrium model with two agents that display the same preferences, and they only differ in their skill level and consequently in the wage rate earned in the market. The sensitivity analysis permits me to identify the drivers that may trigger the phenomenon: the non-homotheticity in preferences, the elasticity of substitution between labour inputs (skilled and unskilled), and differential SBTC across sectors. After calibrating the model to the U.S. industries and labour data from the EU KLEMS dataset, a series of counterfactual experiments allow us to identify the composition of the population and the growth rates for skilled and unskilled agents as other significant elements of the phenomenon. Specifically, a decrease (increase) in the annual growth factor for the high-skilled (low-skilled) population leads to IG situations.

The impact of technological change and the circumstances in which agents' welfare deteriorates are sensitive issues that deserve to be addressed from several perspectives. The following research attempts to provide a detailed theoretical and quantitative analysis that combines the different leverages capable of triggering IG mechanisms. Subsequent extensions of the model will also have to consider the cross-country dimension to extend the significance of the results and obtain more remarkable empirical corroboration.



PhD programme in Legal Sciences

Coordinator: Gianmario Demuro
Vice-coordinator: Silvia Corso

During the 35 cycle and the academic year 2021-2022, the Doctorate in Legal Sciences focused its teaching and training activities, on the relationship between "Power and Responsibility" both from the perspective of the general categories of public and private law, and through more specific perspectives that intersect the different disciplinary areas that are relevant to the Doctorate.

The doctoral students enrolled in the 35th cycle published their results of the research on the need to combine the protection of public health with individual self-determination in the choice of treatment, also in relation to the experienced campaign of a mass vaccination in S. Corso, G. Demuro (eds.), I vaccini tra libertà individuale e solidarietà collettiva, ESI, Napoli, 2023. Although they were not able to carry out their full research periodabroad, the 35th cycle doctoral students carried out remote and in person research activities at qualified foreign universities, enabling them to complete their research work with a view to writing their final dissertation.

https://dottorati.unica.it/scienzegiuridiche/

The independence and impartiality of Italian administrative judges

Lorenzo Marilotti

Born in Cagliari in 1995, in 2016 I graduated in *Pianoforte principale* at G.P. da Palestrina Conservatorium of Music and in 2017 I also graduated *summa cum laude* in Law at University of Cagliari with a dissertation concerning the history of Italian administrative justice from *Ancien Régime* to the Unification of Italy. In 2018 I was appointed as a *cultore di materia* in administrative law. In 2019 I was a research fellow at *Centro Studi e Ricerche Parlamentari Silvano Tosi* of Florence. In 2021 I have been admitted to the Bar of Cagliari as a lawyer.

From 2019 I am a PhD student and my PhD research concerns the independence and impartiality of Italian administrative judges, i.e. the judges who rule on public power and public administration.I carried out my research in collaboration with three foreign Universities. In particular in Spain, with the University of Santiago de Compostela, I was able to evaluate the advantages of the Spanish legal system and the work of the *Consejo General del Poder Judicial*; in China, with the Zhongnan University of Economics and Law of Wuhan, I was able to study how a rising country faces the political problem of the existence of administrative justice and the relationship with the executive power; in Germany, with the *Centre Juridique Franco-Allemand* of Saar University I studied simultaneously the particularities of the French and the German systems.

Through my research I evaluate if the independence and impartiality of Italian administrative judges is sufficiently respectful of the due process clause.

The starting point of this analysis is the fact that administrative justice historically stands at the stormy meeting point between the executive power and the judiciary and in Italy, as it is and as it was in other countries, administrative justice was born even from within the administration. The fact that administrative justice is located in a border area implies that it has undergone strong influences from the executive power capable of compromising its independence and impartiality.

The Italian Constitution has not resolved the most critical issues and, in fact, has provided for a complete system of jurisdictional guarantees for the civil judge (i.e. the judge of disputes between citizens) but has also provided for administrative judges to be separate from civil judges. At the same time, however, the Constitution provides, together with the ECHR and the Charter of Nice, useful starting points for believing that the guarantees provided for the civil judge are applicable, at least as fundamental principles, also to administrative judges.

Since the fundamental guarantees that are applicable to administrative justice obviously also concern independence and impartiality, my thesis focuses on three specific aspects of the administrative justice system as defined by law 186/1982: 1) the system of self-government; 2) the career of administrative magistrates; 3) the interferences between judicial and non-judicial function.

The system of self-government of administrative justice is entrusted to the *Consiglio di Presidenza della Giustizia Amministrativa* (CPGA). It is intended to prevent administrative magistrates from being conditioned by other powers. This system presents several serious problems such as the excessive power of the President of the CPGA, a disciplinary system full of gaps and, most significantly, the fact that it is the same administrative judges subjected to the CPGA who judge on the acts of the CPGA. Equally problematic are non-judicial activities of administrative judges. In fact, in many cases, the administrative activities of administrative magistrates could be the subject of administrative proceedings in which the judges who carried out the non-judicial activity also participate. From this point of view, the positions that administrative magistrates hold in the Government are particularly dangerous.

Marilotti L., Il Sistema del contenzioso amministrativo napoleonico e la sua trasposizione nella Penisola italiana, *Dir. e proc. amm.*, 2021; 3: 763-804.

Loans and Negative Interests

Francesco Sabiu

Francesco Sabiu graduated *cum laude* from the University of Cagliari in 2013, presenting a final dissertation on multilateral development banks. In 2015 obtained a diploma of specialization in legal professions and one year later was admitted to the Italian Bar and to the School of Specialization in Civil Law of the University of Camerino. He started his experience as PhD candidate in 2019, aiming at analysing the relationship between loans and negative interests.

He is author of several publications on banking and financial law. His experiences abroad include an exchange program at the John Marshall Law School in Chicago (USA) and a work stint at an International Law Firm in Cluj-Napoca (Romania).

His thesis focuses on the interactions between loans and negative Interest Rates. Payments of interest amounts in floating rate loans are usually linked to specific benchmarks, such as EURIBOR. In the recent past the above-mentioned reference parameter decreased below the value of zero. In theory this could mean that lenders have to pay (negative) interests to borrowers: a disruptive scenario in the system of loan contracts, in which borrowers are normally required to pay interests to lenders, and not vice versa.

Nevertheless, the nature of non-gratuitous loan contracts suggests that the fall below zero of Euribor or similar benchmarks do not imply that in loans that include a floating rate borrowers deserve to receive an amount of money in the form of negative interests from lenders.

In fact, interests in the Italian legal system are remuneration tools of a lending activity. Therefore, the lender should be ensured of a complete loan repayment: not only the borrower is not entitled to any accreditation, but he is also required to pay the instalments of his debt to the full extent of their capital amount.

Anyway, if the agreement contains specific provisions regulating the event of payment of negative interests, they will apply. For instance, this is the case of loans that include an embedded derivative clause or contracts different from loans, such as Interest Rate Swaps.

Perking-up EU actorness through sustainability in foreign direct investments

Sofia Tzortzi

Lawyer and political scientist specialised in EU law and policy-making. A Greek national, I hold degrees from the University of London (LL.B.), the Sorbonne (BA), the University of Strasbourg (MA) and the College of Europe (MA). While being a certified practicing lawyer in Athens and in Nicosia, I have also worked at the European Commission, the Council of the EU as well as consulting and law firms in Brussels, and I have handled cases tried before the Court of Justice of the EU in Luxembourg and the European Court of Human Rights in Strasbourg. In addition to my past international experience, I am a visiting professor at the Catholic University of Lille. I have also conducted research under the guidance of Professor Ilias Bantekas of the Hamad Bin Khalifa University in Qatar and have completed trainings relevant to my research topic with the University of Athens and the University of Leiden.

My PhD thesis entitled *Perking-up EU actorness through sustainability in foreign direct investments* aims to prove that the EU is effectively enhancing its positioning as a responsible world player in reaching sustainable development through its action in the area of international investment law.

According to my hypothesis, although typically foreign relations are an integral part of 'high politics', 'low politics' such as environment, climate action and trade are nowadays playing a significant part in international relations. The EU has repeatedly failed to position itself as a measurable world player in mainstream foreign relations. Notwithstanding, it has embraced this new role of low politics in international

relations and managed to incrementally be recognised as a significant global actor and even a pioneer in areas such as trade, climate action and environmental protection.

Regarding investments, in the last two decades international investment law has endured severe criticism due to suspected bias towards investors' interests, and a general lack of balance between the protection of public interest and that of investments. Albeit a progressive recognition of the necessity to address these imbalances in the newer generation of investment treaties, enforcement and legal practice is still very problematic, at a large extent because disputes arising between a foreign Investor and a host state is not resolved in ordinary courts but by private justice, i.e., arbitration panels.

Typical international investment law is hence breaching *Union law,* values and sustainability objectives. The Treaty of Lisbon conferred to the EU new powers to regulate foreign investments and conclude international investment agreements with third countries. To ensure compatibility with its laws, the EU legal order has to shape-up its foreign investment differently from the status quo of investment law. Given the external dimension of this policy, these issues are addressed not only internally, but within the EU's relations with the world. The Union has sought to become one of the pioneers in the revamp of international investment law, thus strengthening its world 'actorness' as the forerunner for sustainability. Overall, the EU's endeavours for a 'purge' of international investment law consistent with the Union's legal order, is substantially contributing towards a more responsible, fair and rules-based system and to the positioning of the EU as a responsible world leader, steering towards sustainable development.

Text and data mining exceptions to Copyright as access to information in the Digital Single Market

Matteo Zampella

I am a PhD candidate in Legal Sciences undertaking a doctoral program with a focus on Commercial Law and Intellectual Property Rights, under the supervision of Professor Elisabetta Loffredo.

I graduated in Law at University of Cagliari in 2019, after spending a visiting research stay at the Chair of Law and Human Genome of the University of the Basque Country, with a thesis on Artificial Intelligence and Big Data as new frontiers of Intellectual Property Law. In 2021 I have qualified as a Lawyer at the Bar of Cagliari.

During the doctoral program I have wrote various comments to provisional measures by jurisdictional authorities on the matter of Trademarks and Corporate law. In 2021 I have also been involved in the Sharper's European Researchers' Night, together with the whole doctoral Course in Legal Sciences, on a project involving the legal implications of the COVID-19 pandemic, which led me to the writing of an article on access to patented inventions involving vaccines. In 2022 I have been a visiting researcher at the University of Stirling for a semester, under the supervision of Professor Guido Noto La Diega.

The focus of my work during the doctoral program has mostly dealt with the recent EU Directive 790/2019 on Copyright and related rights in the Digital Single Market (CDSM Directive). Among the provisions introduced by the European legislator in terms of access to data, articles 3 and 4 provide for two different exceptions in the case of Text and Data Mining (TDM or, in general, data analysis) techniques. My

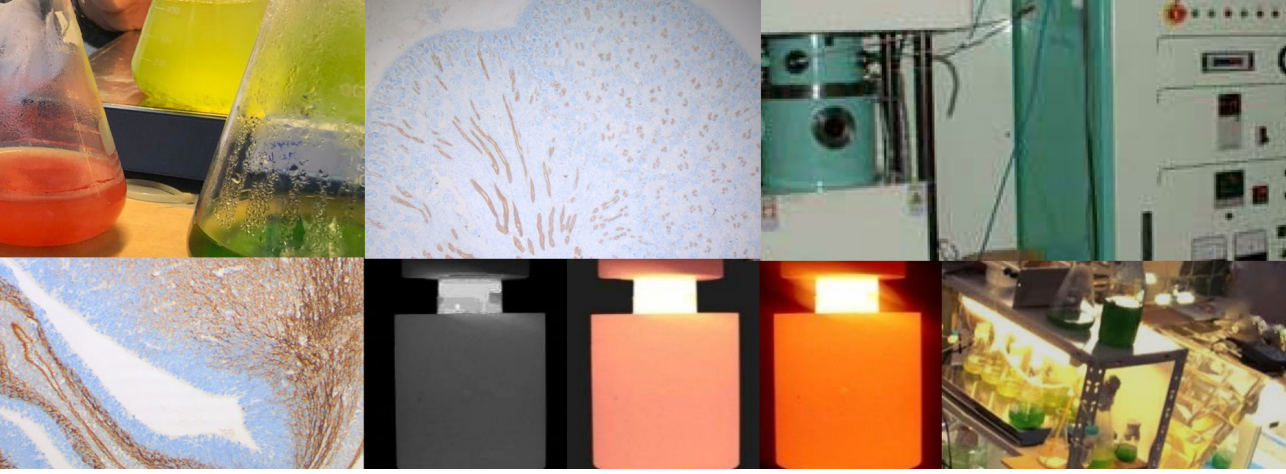
studies allowed me to work on a doctoral thesis on *Access to data and information protected by Copyright through data analysis, between exclusive rights and TDM exceptions*.

In the first part of my thesis, I introduce the relationship between TDM and Copyright. TDM consists in the extraction, through software, of text and data, to interpret and extrapolate information whose output consists in the generation of a knowledge discovery. These techniques stand as a fundamental moment of technological and cultural innovation in the data-driven society, and they have prompted the European legislator to intervene with specific regulations. The recent Copyright Directive is just a piece of a European framework where data is becoming the center of attention, with legislations overlapping in different fields of law, such as the most recent Digital Markets Act and Digital Services Act, that are just the last examples of an already full EU digital agenda.

The second part of my thesis deals with a specifical analysis of the norms involved, especially articles 3 and 4 of the Directive and articles 70-ter and 70-quater of the Italian Copyright Law (L. 633 of 1941, or l. aut.). Art. 3, which operates as a mandatory rule, involves an exception exclusively to research organizations and cultural heritage institutions for scientific research purposes; art. 4, on the contrary, concerns the hypothesis of an exception for private companies through an opt-out clause given to copyright holders. It has been argued that the Directive, instead of encouraging research and access to information, strengthens the position of rightsholders, who would be forced to allow access to their works only to a limited circle of beneficiaries.

This leads to the interpreter's task to make sense of the provisions referred to in art. 4 of the Directive and art. 70-quater l. aut., to justify the introduction of a legislation that would risk to negatively affect access to data. To do this, different solutions may arise: through broader interpretations of the exceptions, or by legitimation of data analysis based on Copyright principles, or, finally, through antitrust regulation.

Zampella M., *Vaccini anticovid e accesso all'invenzione brevettata*, in S. Corso, G. Demuro (eds.), *I vaccini tra libertà individuale e solidarietà collettiva*, ESI, Napoli, 2023.



PhD programme in Innovation Sciences and Technologies

Coordinator: Maria Francesca Casula
Vice-Coordinator: Francesco Delogu

The PhD Course in Innovation Sciences and Technologies started as an international PhD program back in A.Y. 2013/14 based on the positive experience of the international PhD course in Environmental Sciences and Engineering (active from 2001/02, XVII cycle to 2012/13, XXVIII cycle) and of the PhD course in Biomedical Engineering (active from 2010/11, XXVI cycle to 2012/13, XXVIII cycle), no longer active. As a consequence, the PhD Programme in Innovation Sciences and Technologies includes many of the topics which were developed within the aforementioned PhD courses and develops research topics such as those related to materials science and technology.

The PhD Board (a.y. 2022-23, XXXVIII cycle) is constituted overall by 37 members, and in particular by the assistant, associate, and full professors as well as experts in their field listed below in alphabetical order:

Silvia Ajossa, Matthias Angermeyer, Stefano Angioni, Laura Atzori, Doris Barcellona, Pierluigi Caboni, Giacomo Cao, Giovanni Caocci, Mauro G. Carta, Maria F. Casula, Alessandro Concas, Antonio Crisafulli, Guido Crisponi, Francesco Delogu, Sandro Demuro, Enrico Erdas, Fabian I. Ezema, Gavino Faa, Daniela Fanni, Vassilios Fanos, Clara Gerosa, Stefano Guerriero, Giorgio La Nasa, Nicola Lai, Roberta Licheri, Valerio Mais, Gian B. Melis, Ana I. Miranda, Valeria M. Nurchi,

Germano Orru', Roberto Orru' Palmina Petruzzo, Giorgio Pia, Luca Pilia, Massimo Pisu, Angelo Restivo, and Annalisa Vacca.

The PhD Course is intended to introduce, through a multidisciplinary approach, young graduates to topics related to both basic and applied research, and is organized based on three curricula:

1) Regenerative medicine, biomedical engineering and management of complex healthcare systems;

2) Methods and systems for environmental protection;

3) Methodologies and processes for the transformation and use of materials.

The broad range of topics covered by the PhD within the three aforementioned curricula can be inferred by the list of some recently awarded PhD thesis:

2020/2021 (XXXIV cycle):

- GIACOMO FAIS (In association with Universitat de les Illes Balears (UIB), Palma, Illes Balears, Spain – Advisors: Prof. Giacomo Cao, Prof. Jeroni Galmés) – Thesis: Microalgae for deep space exploration
- SARA MAGNANI (Advisor: Prof. Antonio Crisafulli) – Thesis: Characterisation of systolic and diastolic functions with echocardiography imaging in healthy populations subjected to stress manoeuvres
- ANDREA PINNA (Advisor: Prof. Luca Pilia, co-advisor Prof. Giorgio Pia) – Thesis: Nanoporous Metals: Fabrication and Structure-Properties Relationship
- DANIELE TROGU (Advisor: Prof. Sandro DeMuro, co-advisor Prof. Giovanni Coco) – Thesis: On the role of biomass on coastal morphodynamics in natural and urban Mediterranean beaches

2019/2020 (XXXIII cycle):

- BLESSING C. EZEALIGO (Advisor: Prof. Giacomo Cao) – Thesis: Fabrication and characterization of barium titanate based ceramics material
- VIRGINIA PINNA (In association with Radboud University – Advisors: Prof. Antonio Crisafulli, Prof. Dick Thijssen) – Thesis: The cerebral circulation and oxygenation in response to sympathetic stress in ageing and in patients with metabolic disorders

- MARTINA PIRAS (Advisor: Prof. Mauro G. Carta) – Thesis: Validation of a genetic screening tool for bipolar disorder
- HEMA SEKHAR REDDY RAJULA (Advisor: Prof. Vassilios Fanos) – Thesis: Study of Metabolomic Networks associated with Autism and Schizophrenia
- GIORGIA TESTA (Advisor: Prof. Mauro G. Carta) – Thesis: A randomized controlled trial on the use of biofeedback with wireless technology in the therapy of fibromyalgia
- GABRIELE TRAVERSARI (Advisor: Prof. Alberto Cincotti) – Thesis: Analysis of multi-phase systems relevant to bioengineering and materials science

https://sites.unica.it/internationalphdist/

Innovative Apatite/Bioactive Glass-based materials for biomedical applications

Damiano Angioni

Born in Cagliari, I was interested in science from a young age. Due to my desire to understand more about nature and its laws, I decided to study Physics. I graduated in Physics at the University of Cagliari, first and second level, with thesis related to the properties and optical behaviour of innovative materials. Then, I decided to make some work experience, and I was employed for one year as a software developer. In the meantime, I applied for a Ph.D., and in 2019 I started my doctoral programme in Innovation Sciences and Technologies.

Due to their scientific interest, I joined a project related to the development of materials for biomedical applications. In particular, the focus of my work is the production and characterisation of novel materials able to stimulate a positive response when implanted in the human body, specifically bio-ceramics, bioactive glasses, and their composites. During my Ph.D., I had the chance to spend 6 months as a visiting student at the Imperial College of London, where I worked on the assessment and optimization of the production of bioactive glass fibres by the electrospinning technique.

My three years of work resulted in the thesis titled *Innovative Apatite/Bioactive Glass-based materials for biomedical applications*. The guiding thread of my thesis is the combination of novel biomaterials together with innovative processing routes to overcome the drawbacks of the products currently used. To this, I worked on the production of bulk samples of apatites (most similar material to the inorganic part

of human hard tissues, like bone, dentine, and enamel), and bioactive glasses (able to bond to hard and soft tissues in the human body, and to stimulate the formation of new biological tissue, after implantation). In addition, I combined the two previous classes, to obtain products both taking advantage of the benefits of the constituents and limiting their drawbacks. More importantly, such composites can be possibly developed to tune their biological response according to the clinical need, by changing their composition. The properties of such materials, vastly employed in the biomedical field, can be further improved depending on their processing route. For this reason, in one of my works, *Angioni et. al 2022*, it was decided to combine a mechanical treatment of the composite powders, called ball milling, and a non-conventional densification technique, called Spark Plasma Sintering, to obtain bulk products showing excellent biological behaviour in preliminary acellular tests.

In conclusion, the research work carried out during the Ph.D. programme is intended to provide a useful contribution to the research regarding biomedicine, and in particular regenerative medicine, by the combination of novel materials and processing routes, to possibly tune their properties according to the specific clinical need.

Angioni D., Orrù R., Cao G., et al., Bioactivity Enhancement by a Ball Milling Treatment in Novel Bioactive Glass-Hydroxyapatite Composites, Journal of the European Ceramic Society, 2022, 3(43): 1220-1229

Optimization of High Entropy Borides for Advanced Applications

Simone Barbarossa

Born in Cagliari. The curiosity to understand and explain any natural event has encouraged me to pursue a career in science. This led me to begin my formation in the Physics course at the University of Cagliari, where I graduated at the Bachelor and Master levels. As a result of the research of my Master thesis, my first scientific contribution was made, based on the investigation of the optical properties of an organic polymer for lightning applications.

With the aim of continuing my formation in the material sciences field of research, I began to work as a research assistant in the Mechanical, Chemical and Materials Engineering Department, which soon developed into a Ph.D. student position in 2019.

My research project was focused on the investigation of the novel High Entropy Borides (HEBs) class of ceramic materials. These are based on the combination of five or more metal cations, distributed in near-equimolar percentages to produce a single-phase crystalline solid solution. The HEBs can be also classified as subclass of a more general class of ceramics called the Ultra High Temperature Ceramics (UHTCs). The UHTCs are known to possess impressive properties in terms of high melting temperatures (about 3000 K), high hardness, good electrical and thermal conductivities, solar spectral selectivity, among many others, and are widely of interest in fields of application such as solar energy farms, aerospace (hypersonic flights and/or space re-entry vehicles), etc. However, conventional UHTCs are falling short

to satisfy the increasing demand of components able to withstand ever increasing extreme conditions, where the combination of high temperatures, oxidising environment, and wear are met.

Since 2016, the research focused on the HEB class has increased exponentially due to its promising properties, suggesting higher performances with respect to their conventional UHTCs counterparts, such as hardness and oxidation resistance properties.

My three-year Ph.D. project, by the title: *Optimization of High Entropy Borides for Advanced Applications*, provides a further contribution for the literature on the optimization of the processing conditions for the obtainment of HEB products in bulk form. Within the latter, usual issues addressed during my Ph.D. course include the presence of secondary phases, such as inter-metallics or oxide contaminants, low densification of the bulk product, chemical homogeneity, etc.

The investigation of the latter ones was performed by an alternative processing route, composed of the Self-propagating High-temperature Synthesis (SHS) for the synthesis of the reactants into the products in powder form, and their subsequent consolidation via Spark Plasma Synthesis (SPS).

A systematic investigation on the effect of the addition of graphite to the powders prior consolidation, presented in the scientific article *Barbarossa et al. 2020*, was followed by more three papers which addressed the sintering temperature effect on the final products and their mechanical and optical properties.

Moreover, my last of the Ph.D. course included a research period abroad, in the Queen Mary University of London, UK facility.

S. Barbarossa, R. Orrù, S. Garroni, R. Licheri, G. Cao. Ultra high temperature high-entropy borides: Effect of graphite addition on oxides removal and densification behavior. Ceram. Int. 2021, 47(5) 6220-6231.

Towards an evolutionary perspective of bipolar disorders: Is there a genetic link between bipolar disorders and non-pathological (adaptive) hyperactivity?

Goce Kalcev

My interest in neuropsychiatry as a medical doctor led me to pursue a PhD in Innovation Sciences and Technologies, where I combined my clinical and research interests, focusing on finding genetic associations between bipolar disorders and non-pathological (adaptive) hyperactivity.

During my PhD study, we developed and validated a new tool, the Questionnaire for Adaptive Hyperactivity and Goal Achievement (AHGA), representing an innovative approach to hyperthymic features by embracing a broader concept of spectrum, which conceptualizes as a continuum the potential transition between pathological and adaptive aspects. The two basic components of the hyperthymic temperament that stand out are hyperactivity and goal achievement. This kind of temperament can be classified as abnormal only in the presence of chronic hypomanic symptoms or advanced mood disorders. In general, temperaments have been verified to belong to the domain of normality rather than the sphere of pathology, in accordance with their putative adaptive role. Commonly, achieving success, experiencing excitement and joy, and moving towards core life goals are moments of great importance in life. In this approach, goal and drive achievement demonstrates an adaptive and beneficial side of hyperthymia. It indicates the willingness to set high goals and spend energy pursuing them, which could help clarify the high rates of creative efforts among people with a hyperthymic temperament. How-

ever, the pathological scenery appears linked to variability in the adaptiveness with which people follow life goals and accomplishments.

In the later stages of the study, this tool was very helpful in identifying older adults (60 years of age and older) with features of well-defined hyperactivity and novelty-seeking. The Questionnaire for Adaptive Hyperactivity and Goal Achievement (AHGA) measures the adaptive characteristics of hyperactivity and goal pursuit in contrast to the Biological Rhythms Interview of Assessment in Neuropsychiatry (BRIAN) tool, which measures its pathological characteristics. According to the results regarding the investigated genetic variant (RS1006737) of the CACNA1C gene, an association was found with the characteristics of hyperactivity rather than just BD. Also, this genetic variant, recognized in the literature as associated with bipolar disorders, was found in well-adapted older adults without bipolar disorders and high hyperactivity traits with a similar frequency as in older adults with a diagnosis of bipolar disorders but higher than in older adults without bipolar disorders and without hyperactivity. This could led to the new interpretation and a new approach to supporting drug therapy in which the rediscovery of the adaptive potential resources would be central to the recovery of the individual who has suffered a bipolar disorder onset. Furthermore, the interpretation of the disorder not as the simple consequence of a genetic weakness could be an element against stigma and self-stigma. When comparing the biological material, although saliva and blood differ in composition and biological properties, sample type has no effect on the detection of a mutation in the genetic variant of interest. Blood and saliva can both be used as biological materials in later stages of this research.

The combination of the new questionnaire tool (Questionnaire for Adaptive Hyperactivity and Goal Achievement) with the genetic analysis appears to be an innovative, practicable, and original approach. The following development of this study will include more genetic variables with higher susceptibility for bipolar disorders (ANK3, NCAN, ODZ4, SYNE1, and TRANK1 genes) and obviously more numerous target and control samples.

Kalcev G, Preti A, Scano A, et al. Insight into susceptibility genes associated with bipolar disorder: a systematic review. European review for medical and pharmacological sciences, 2021; 25(18): 5701-5724.

Metabolic changes in human erythrocytes and plasma under simulated microgravity conditions

Cristina Manis

I attended the degree course in Toxicology at the University of Cagliari, graduating in February 2016. After the bachelor's degree, I obtained a master's degree in clinical, forensic and sports chemistry at the University of Turin. In October 2019 I started the PhD course in science and technologies for innovation mainly dealing with research in the field of astrobiology.

My PhD thesis entitled "Study of metabolic changes in human erythrocytes and plasma under simulated microgravity conditions" is a result of the work of three academic years in the Doctorate school of "Innovation Sciences and Technologies" at the University of Cagliari (Italy). The aim of the project was to investigate the metabolomic profiles of human plasma and erythrocyte samples trying to identify possible alterations identifiable as effect of the microgravity environment developing new analytical methods for the analysis of biological sources. The first and the second year were spent in Cagliari, at the Department of Life and Environmental Science and at the Department of Mechanical, Chemical and Materials Engineering where I analysed the lipid profile of human erythrocytes samples using Ion Mobility/Quadrupole-Time-of-Flight Mass Spectrometry (UHPLC-IM-QTOF-MS). In January 2022, I started an internship at The Centre of Metabolomics and Bioanalysis (CEMBIO) at the CEU-San Pablo University, Madrid, where I performed the analysis of polar profile of human plasma samples using capillary electrophoresis coupled to mass spectrometry (CE-MS). The spatial anaemia in astronauts has

been noted since the earliest space missions, but the mechanisms remained unclear. To understand the biological mechanisms underlying aerospace anaemia we investigated the metabolic changes that occur in the erythrocytes and in human plasma under low gravity.

Erythrocytes exposed to low gravity showed morphological changes, increase in reactive oxygen species, significant reduction in total antioxidant capacity, remarkable and constant decrease in total glutathione concentration, and an increase of malondialdehyde levels.

Lipidomics results showed an upregulation of phosphocholines and sphingomyelins levels. Alterations in the lipid composition can determine membrane rigidity and fluidity, and plays a crucial role in membrane organization, dynamics, and function. Additionally, a different fatty acid composition of membrane components can result in a greater sensitivity to peroxidative stress, with a consequent increase in membrane fragility. Phosphatidylcholine species containing polyunsaturated fatty acids in their moiety are susceptible to free radical oxidation. The analysis performed during my PhD course revealed a double mechanism that generates the reduction in the red blood cells number. There is an increase in the levels of phosphocholines containing arachidonate which induces a reduction of cellular proliferation. On the other hand, the mitochondrial damage, caused by microgravity, produce an accumulation of Hexosylceramide which acts as a pro-apoptotic signal condemning the erythrocytes to death.

In conjunction with these results, the metabolomics analysis revealed that microgravity in human plasma induced an increase of glycolysis, Krebs cycle and fatty acids β-oxidation perturbations, and lactic acid production. These findings indicate an evident damage of circulating mitochondria causing a defective respiratory chain, oxidative environment, and incomplete β-oxidation of fatty acids with consequent accumulation of carnitines, propionyl carnitine.

The implications of this research work will be able to provide a useful contribution both to the understanding and the potential prevention of the health risks associated with astronauts involved in deep space exploration scenarios.

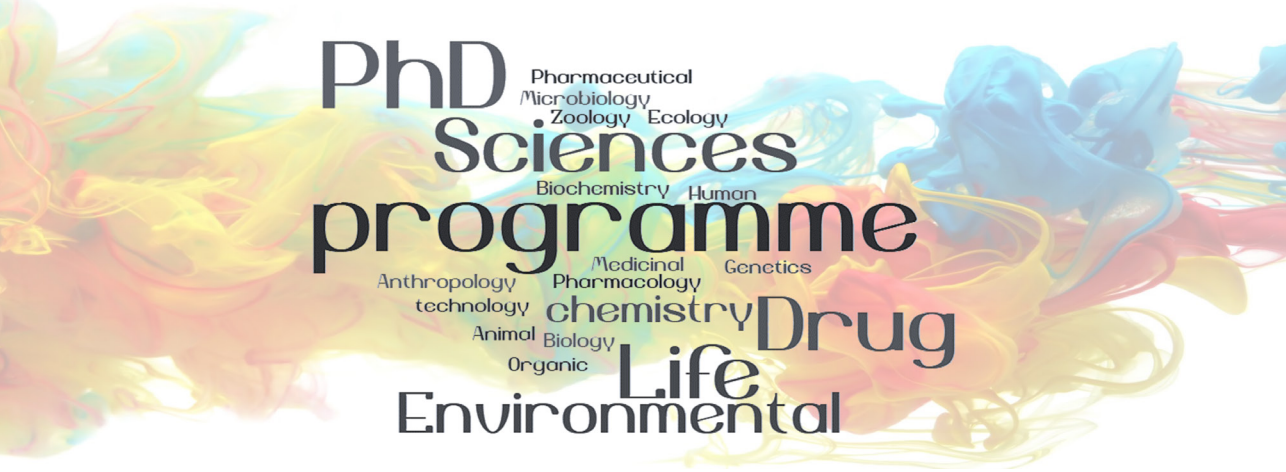
Virtual Reality in Bipolar Disorders: a Recovery-Oriented Cognitive Rehabilitation tool

Alessandra Perra

The passion for research in mental health field has started since the beginning of my university career, thanks to the presence of prof. Mauro Giovanni Carta (PhD Supervisor). Actually, I am a PhD student in Innovation Sciences and Technologies-Scientific Disciplinary, Sector of Regenerative Medicine and Biomedical Applications – XXXV Cycle. I graduated in Psychiatric Rehabilitation Technician at the University of Cagliari in 2016. Then I got a master's degree in health Professions if Rehabilitation Sciences at the University of Cagliari in 2018. During both graduation I had the opportunity to take part to different research project and also in 2015 in Buenos Aires and in 2017 in Bruxelles to Erasmus Program. My focus at first was on the study of psycho-social-wellbeing and respect of human rights in healthcare professionals, in general population and migrant population. Working with psycho-social disabilities confronts you with the importance of taking health needs at the center of the research objectives.

From this general experience started my PhD project. It concerns the cognitive remediation rehabilitation with innovative instruments for the treatment of cognitive deficits in bipolar disorders. Cognitive impairment is a frequent consequence of bipolar disorder, that is difficult to prevent and treat. The quality of the preliminary results on the treatment of bipolar disorders through cognitive remediation with traditional methods is poor. In general, actually systematic review in the scientific literature suggested that virtual reality has a positive impact

on cognitive and functional outcomes in people with mental disorders and neurodegenerative disorders. For this reason, with this PhD project was evaluated the feasibility, and a preliminary data on the efficacy, of Cognitive Remediation interventions with fully immersive Virtual Reality as an additional treatment for bipolar disorders. To evaluated it was made a feasibility randomized controlled cross-over clinical study, were randomized 50 people with bipolar disorder diagnosis treated at the psychiatric Unit of the University Hospital of Cagliari. The experimental group received a CR fully immersive VR recovery-oriented program for 3 months (2 sessions per week) plus conventional care, whereas the control group only received the conventional care program. The results are preliminary and cannot be considered exhaustive due to the small sample size. However, the evidence of efficacy, together with the excellent acceptability of the intervention, are of interest and suggest the need to conduct studies with larger samples that can confirm this data. Thanks to this project different research group in Italy has started a collaboration in order to evaluate the feasibility and efficacy of virtual reality cognitive remediation program for different mental health disorder. The findings obtained during the PhD are present in the thesis "Virtual Reality Frontiers in Bipolar Disorders: A Recovery Oriented Cognitive Rehabilitation tool".



PhD program in Life, Environmental and Drug Sciences

Coordinator: Prof. Cristina Follesa
Vice-coordinator: Prof. Simona Distinto

The PhD program in Life, Environmental, and Drug Sciences offer to the students the opportunity to work in a multidisciplinary setting with a wide range of interests and research goals. It is divided into three curricula:

- *Biomedical*, in which students focus on research activities in the fields of biochemistry, genetics and microbiology;
- *Human and Animal Biology and Ecology*, in which students focus on research activities in the fields of anthropology, ecology and zoology;
- *Drug Sciences*, in which students focus on research activities in the fields of organic and medicinal chemistry, pharmacology, and pharmaceutical technology.

The cross-curricular collaborations give students the chance to consider various aspects of the life sciences.

The PhD Board involves 32 qualified Professors of the Department Life and Environmental Sciences with multidisciplinary expertise and international collaborations. In alphabetical order: Elio Acquas, Pieran-

tonio Addis, Gianfranco Balboni, Tiziana Cabras, Carla Maria Calò, Caddeo Carla, Rita Cannas, Alessandro Cau, Angela Corona, Filippo Cottiglia, Danila Cuccu, Giovanna Delogu, Simona Distinto, Francesca Esposito, Antonella Fais, Anna Maria Fadda, Maria Cristina Follesa, Francesco Lai, Elias Maccioni, Maria Letizia Manca, Barbara Manconi, Maria Manconi, Elisabetta Marini, Rita Meleddu, Valentina Onnis, Francesca Pintus, Antonio Pusceddu, Andrea Sabatini, Chiara Sinico, Vitale Sparacello, Enzo Tramontano and Carlo Tuberoso.

The PhD Board activated international agreements with an Asian university (Taipei Medical University) and a European university (University of Porto), allowing doctoral students to earn a dual international degree.

PhD students graduate with high competencies in their investigational areas, complete judgment autonomy, adequate communication skills, and a high ability to apply new technologies in several research areas.

Doctoral students in the XXXV cycle are all highly motivated and have acquired the autonomy to complete original research projects on the topics covered by the doctorate program.

They will graduate with an enhanced CV that includes several publications, seminars, summer schools, and participation in national and international conferences. During these three years, they assisted with teaching and tutoring in a variety of Biology and Pharmacy Faculty courses.

Their the research activity took place both in Cagliari and at foreign institutions. In particular, they had the opportunity to work at the Centre International de Recherche en Infectiologie- Université Lyon; Instituto de Ciencias del Mar del Consejo Superior de Investigaciones Científicas (ICMCSIS) of Barcelona; Institute for Global health, and Nanoscience and Nanotechnology Institute, University of Barcelona; Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, České Budějovice, Czech Republic, University of Aveiro, CEFREM, University of Perpignan, France and the School of Chemistry of the Cork University College.

https://corsi.unica.it/sciviamfa/

Effects of disturbance on sedimentary organic matter in aquatic ecosystems

Claudia Ennas

Born in Cagliari in 1993, I graduated in Biology in 2016 at the University of Cagliari with an experimental thesis about the eradication measures of coypu (*Myocastor coypus*) in the river basins of the Cagliari Province. Then, I received my master's degree in Marine Bio-Ecology Cum Laude at the University of Cagliari in 2018, with an experimental thesis entitled "*Long term variations in trophic status and degradation rates of organic detritus in bathyal sediments of the Ross Sea (Antarctica)*", under the supervision of Prof. Antonio Pusceddu. After that, in October 2019 I joined the PhD Program at the University of Cagliari, under the supervision of Prof. Antonio Pusceddu.

My PhD thesis, entitled "*Effects of anthropogenic and natural disturbance on organic sedimentary loads in river, lagoon, and marine-coastal environments*", has been undertaken in the framework of two projects: "Effects of climate environmental shifts on species, communities and ecosystems", funded by the Fondazione di Sardegna (call 2018), and "Marine habitats restoration in a climate change-impaired Mediterranean Sea (MAHRES)", funded by the Italian Ministry of Research (PRIN, call 2017). The aim of my PhD thesis was to study the ecological effects of selected disturbance typologies on the quantity, biochemical composition, nutritional quality, and degradation rates of sedimentary organic matter (OM) in different aquatic ecosystems. First, I investigated the effects of the disturbance caused by bottom trawling on the Baltic Sea seabed, in the framework of a collaboration with the Uni-

versity of Stockholm (Prof. Clare Bradshaw). This study revealed that bottom trawling can lead to a decrease of OM loads and to variable modifications in its nutritional quality and degradation rates. Then, I investigated the effects of field simulated marine heatwaves (MHWs) on sedimentary OM of coastal marine sediments, in collaboration with the University of Sassari. This study revealed that MHWs can be associated with an increase of sedimentary OM loads along with variations in its nutritional quality and turnover times. Then, in collaboration with Prof. Pierantonio Addis (University of Cagliari), I also investigated in mesocosm the possible use of the Mediterranean sea cucumber *Holothuria tubulosa* (Gmelin, 1788) as a bioreactor to counteract benthic eutrophication under different scenarios of sea warming due to climate change. This study led to reveal that sea cucumbers can influence sedimentary OM pools under different temperature regimes and once exposed to sudden heat peaks. Finally, I investigated the effects of anomalous rainfall events on sedimentary OM of a river and a coastal lagoon, both in the field and in mesocosms. In this context, as a visiting PhD candidate, I spent six months at the Institute of Marine Sciences (ICM-CSIC) of Barcelona (Spain) under the supervision of Dr. Pere Puig and collaborating with Dr. Albert Palanques for the analysis of grain size, total organic C contents, and stable C and N isotopes in river and lagoon sediments. The results of these experiments revealed that anomalous rainfall events can severely influence sedimentary OM quantity, biochemical composition, and nutritional quality.

Part of the results of my PhD thesis have been published[1] .

[1]Soru S., et al., *Effects of Field Simulated Marine Heatwaves on Sedimentary Organic Matter Quantity, Biochemical Composition, and Degradation Rates*. Biology, 2022; 11(6), 841.

Development of new nanosystems tailored for the treatment of malaria

Federica Fulgheri

I graduated in Pharmaceutical Chemistry and Technology in 2018 from the University of Cagliari, with the experimental thesis "N-phenylpyrrolamides derivatives as dual target ligands: DNA gyrase b/topoisomerase IV inhibitors". My research work was carried out at the Faculty of Pharmacy of the University of Ljubljana under the supervision of Assoc. Prof. Nace Zidar, Prof. Danijel Kikelj and Prof. Elias Maccioni. In 2018, I spent a period at the Faculty of Sciences of University of Porto, where I worked on the synthesis and characterization of multi-target therapeutic compounds, under the supervision of Prof. Fernanda Borges.

In 2019, I joined the XXXV Cycle of PhD program in Life, Environmental and Drug Sciences at the University of Cagliari, with a scholarship funded by PON R&I, under the supervision of Prof. Maria Manconi.

During my academic years, I had the chance to work in various laboratories, giving me the opportunity to learn many different techniques, meet wonderful people and grow personally and professionally.

My PhD thesis is focused on the development of *innovative therapeutic nanosystems for the treatment of malaria infection.* Malaria is an infectious disease caused by parasites of the genus *Plasmodium*, worrisome in endemic countries. The current treatment is represented by artemis-

inin-based combination therapy, which consists on the administration of a derivative of artemisinin with a partner drug.

Trying to improve malaria therapy and patient compliance, after accurate bibliographic research, I decided to formulate phospholipid vesicles or nanoemulsions containing artemisinin, and to combine it with a second natural compound with antimalarial activity. Overall, results disclosed that nanoemulsions are more effective than phospholipid vesicles in improving the efficacy of these drugs in vivo. Artemisinin and quercetin (5 mg/ml) were simultaneous loaded in a nanoemulsion containing castor oil, kolliphor RH40, soy lecithin and bi-distilled water. The components were heated at 50 °C for 20 minutes, mixed and sonicated with a high intensity ultrasonic disintegrator. Thus, a transparent oil-in-water nanoemulsion was obtained, formed by droplets sized around 60 nm, monodispersed, and negatively charged. The cryogenic transmission electron microscopy confirmed the formation of nanosized droplets plus some phospholipid vesicles.

To complete the study, I spent 9 months in Barcelona, where I joined Nanomalaria research group (ISGlobal, IBEC) to conduct the *in vitro and in vivo* experiments. *In vitro* cytotoxicity against two different cellular lines (Caco-2 and HUVEC) was assessed, confirming the biocompatibility of prepared nanoemulsions. *In vitro* growth inhibition assay on *P. falciparum* displayed that the nanoemulsion simultaneously containing quercetin and artemisinin increased the antimalarial activity versus that of artemisinin in solution. This result was confirmed by *in vivo* experiment. The artemisinin and quercetin containing nanoemulsion was orally administered to mice infected with P. yoelii yoelii 17XL and was able to increase the survival of the animals compared to that of the animals that were not treated or treated with the solutions of artemisinin or quercetin. Results suggested their potential use for the treatment of malaria infection.

Topic-Drivers and effects of plastic contamination in aquatic ecosystems

Pankaj Avinash Gorule

Pankaj Avinash Gorule is originally from Pune, India. He has completed his graduation in Zoology (M.Sc., 2016) from Savitribai Phule Pune University (Formerly University of Pune), India. During his academics, he was engaged in several research projects working on freshwater fishes of the Indian subcontinent with emphasis on the molecular systematics, diversity, and conservation of endemic and threatened taxa of the Western Ghats (Biodiversity Hotspot). He has also been an active volunteer in preparation of Book on Freshwater Fishes of Western Ghats of Maharashtra which is published by Maharashtra Forest Department, Government of India. The vast exposure to laboratory skills like the osteology, histochemistry and genetic data analysis complemented with fieldwork for species collection, ecological observations and threat assessment motivated him to publish the results in peer reviewed journals including Acta Histochemica, Journal of Vertebrate Zoology and Journal of Applied Ichthyology.

In October 2019, he joined the Ph.D. program in Life, Environmental and Drug Sciences at the University of Cagliari with a scholarship funded by MIUR. He is supervised by Prof. Maria Cristina Follesa and Dr. Alessandro Cau. During his study he also had an opportunity to work as intern Ph.D. student with Dr. Marek Šmejkal, Institute of Hydrobiology, Biology Centre of the Czech Academy of Sciences, České Budějovice, Czech Republic.

His Ph.D. project mainly focuses on the study of the factors and effects of Plastic contamination in aquatic ecosystems with the one of the major works focusing on the seafloor litter along Sardinian fishing grounds and potential effects of its fragmentation on benthic fauna. His study aimed to test whether different litter categories may result in geographically segregated seafloor litter hotspots as per the MEDITS Survey protocol from depth 10-800 m, thus providing useful guidelines for prioritizing eventual mitigation action foreseen in the framework of plastic reduction policies. The rapid production and utilization of plastics in various ways has generated a drastic rise in its environmental release over the past few decades. Microplastics (MPs), which are plastic particles of dimension comprised between 1 and 5mm, have been widely detected in all oceanic matrixes, including biota. His study aims to assess and compare for eventual significant differences in microplastic contamination for two ecologically relevant decapod crustaceans dwelling in European Waters: the European spiny lobster Palinurus elephas and the Norwegian lobster Nephrops norvegicus. These species also have a remarkable economical relevance since both are internationally referred as gourmet food. He presented the results of this study in the XXV Congress of the Italian Association of Oceanography and Limnology (June 2021). He also investigated the effects of sub-lethal exposure of polyethylene (PE) and Tire Wear Particles (TWP) affecting the invasive gibel carp (Carassius gibelio) and native crucian carp (Carassius carassius). His study was based on the comparison of the behavioral parameters (boldness, activity and open field test) for the chronic and acute exposures. His study will contribute to the present literature that if higher doses of longer exposure to pollutants would lead to more pronounced changes and whether such changes would be relevant for interaction with other organisms, especially with predators.

Cau, A., et al., Scattered accumulation hotspots of macro-litter on the seafloor: Insights for mitigation actions. *Environmental Pollution*, 292, 118338 (2022).

Salivary proteomics for diseases biomarkers discovery

Giulia Guadalupi

Giulia received master's degree in Cellular and Molecular Biology in 2018 with a research project carried out in the Laboratories of Plant Physiology and Photobiology of the University of Cagliari. During her studies she spent a period of three months at the European Synchrotron Radiation Facility in France working on structural characterization of enzymatic intermediates by x-ray crystallography. In October 2019 she joined the XXXV cycle of PhD in Life, Environmental and Drugs Sciences (Biomedical Curriculum) under the supervision of Prof. Barbara Manconi. Her research activity took place at the Proteomics Laboratory in the Biomedical section of Department, and it was focused on the study of the proteome and peptidome of biofluids, cells and tissue extracts through Mass Spectrometry for the characterization of potential disease biomarkers and bioactive peptides. In 2021, she joined the research group of the Mass Spectrometry Center of University of Aveiro (Portugal) as Erasmus PhD student where she developed part of the PhD thesis.

Giulia PhD thesis entitled "*Salivary proteome investigation for Autoimmune Liver Diseases classification and biomarkers discovery*", proposed to analyze the saliva of patients suffering from two autoimmune liver diseases, named Autoimmune Hepatitis and Primary Biliary Cholangitis, through Mass Spectrometry-based top-down and bottom-up proteomic approaches. The aim of the study was to evidence possible qualitative and/ or quantitative differences of salivary proteins and

peptides characteristic of those pathologies and useful for the discovery of new biomarkers.

Despite advances progress in the understanding of the etiopathogenesis and therapeutic approach of these liver diseases, critical issues remain, especially concerning the early diagnosis. New noninvasive biomarkers are urgently needed, and saliva represents an ideal biological fluid since its non-invasive and unexpensive collection. Salivary proteome is a mirror of physio-/ pathological conditions because it contains not only proteins specifically secreted by the salivary glands but also from other organs and tissue. Proteomic-based approaches allows to analyze at the same time thousands of proteins and peptides, and the combination with Mass Spectrometry represents a valid tool for identification of potential salivary biomarkers, taking advantage of high yield, sensitivity, accuracy, and selectivity of technologically advanced methodologies, like artificial intelligence for proteomics data analysis. During the study, both the acidic-soluble and the acidic-insoluble salivary fractions were analyzed, utilizing top-down and bottom-up Liquid Chromatography coupled to Mass Spectrometry proteomics platforms. Artificial intelligence was used for statistical interpretation of salivary proteomics data from patients in comparison with healthy controls to outline possible protein profile candidate for patients classification and diagnostic biomarkers identification.

Results identified altered levels of proteins related to the immune system and the inflammation cascade suggesting that saliva reflects the pathological systemic condition typical of autoimmune liver diseases.

Bio-ecological and anatomical aspects of the European eel *Anguilla anguilla* (L.)

Cinzia Podda

I graduated with honors in Marine Bio-Ecology at the University of Cagliari in July 2016 defending the thesis *Interaction between environmental factors and space-time distribution: modelling applied to the Mediterranean Aristeids* supervised by Prof. Andrea Sabatini. In 2017, I was rewarded from the University of Cagliari for the best thesis of the Faculty of Biology and Pharmacy, with the Merit Scholarship for the Master Degree in Marine Bio-ecology, and I won the national award "Premio Majorca" for my thesis. After graduation I held a six-months extracurricular Internship about the study of freshwater ecosystems and the management of salmonid areas with focus on the native Sardinian trout (*Salmo cettii*). Afterwards, until September 2019, I held a fellowship on the study of *Anguilla anguilla* recruitment and on its population composition in Sardinia, according to the regional Eel Management Plan (Reg. CE 1100/2007). In 2019 I have been visiting scientist at the Institut Tour du Valat and at the University of Perpignan (France) for the study of the eel ecology.

The PhD research has allowed me to publish, as the first author, four articles in international journals and to present eight contributions and win three different awards for the best presentation in national congresses.

During my PhD my research focused on the *Study of some ecological and biological aspects of the European eel* under the supervision of Prof. Antonio Pusceddu and Prof. Andrea Sabatini. The thesis aimed to

deepen the knowledge about the life cycle and the migratory propensity of the European eel, whose complexity and peculiarities exposed it to several anthropogenic pressures that, overtime, determined its decline since 1970s[1].

A series of sampling activities followed by laboratory experiments and uni- and multi-vairate statistical analyses allowed first demonstrating the presence of synaptic development in the olfactory bulb according to a pattern linked to the two migratory life stages (i.e., glass eels and silver eels). Furthermore, the recruitment temporal peak was determined in Sardinia by using two monitoring techniques, and differences in the recruitment patterns in the western Mediterranean basin have been described across multiple sites. Eels' survival and growth were studied during a rearing experiment after restocking. The decrease in eels' occurrence because of dams' building in Sardinian rivers was investigated and last, the first evidence of microplastic ingestion by resident yellow eels caught in a small Mediterranean stream was revealed.

In the context of an international collaboration with the University of Perpignan - CEFREM (France) I also worked six-months with Dr. Elsa Amilhat and Dr. Elisabeth Faliex on the study of eels' growth by using otolithometry, and on the glass eels' recruitment in multiple sites of the western Mediterranean basin.

The results achieved by my research might have several implications beyond the regional interest and add new cues from which start further investigations. These, in turn, might guide the future implementation of new studies and appropriate monitoring programs, highlighting also an urgent need for collaboration between stakeholders, researchers, decision-makers, authorities, professionals, and common people as an essential step to creating a sense of awareness on the criticalities that impact this species and the need of mitigating them.

[1]Podda C. et al. Hard times for catadromous fish: the case of the European eel *Anguilla anguilla* (L. 1758). Adv. Oceanogr. Limnol., 2021; 12 (2): 9997. doi: 10.4081/aiol.2021.9997.

Investigating new scaffolds for multi-target anticancer approach

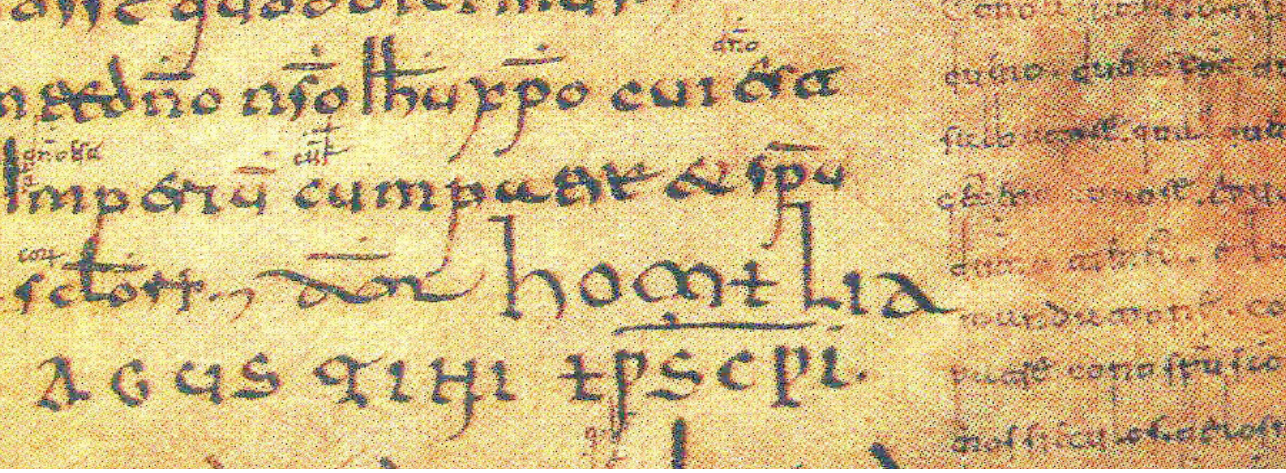
Daniela Secci

Daniela graduated in Pharmaceutical Chemistry and Technology at the University of Cagliari in 2018, discussing a research thesis entitled "Poli-pharmacological approach to anticancer therapy". During her studies, she spent six months at the Department of Pharmaceutical Chemistry, at the Faculty of Pharmacy in Ljubljana to perform the research work for her Master's thesis, under the supervision of Professor Lucija Peterlin Mašič and Daniel Kikelj, and the home mentorship of Professor Elias Maccioni. After her graduation, she has been enrolled as research fellow at the Department of Pharmaceutical Chemistry of the Faculty of Pharmacy in Ljubljana, from January 2019 to November 2019, under the supervision of Professor Daniel Kikelj.

The research purpose was the optimization and design of biologically active molecules against Gram negative bacteria, directed to the DNAgirase B. This research was performed within the frame of the ENABLE project, part of the IMI initiative 'New Drug For Bad Bugs' (ND4BB). In December 2018 she was enrolled in the PhD program In Life, Environmental and Drug Sciences (Drug Sciences Curriculum), under the supervision of Professor Elias Maccioni. As a PhD student, she is involved in a project dedicated to the identification, design, and synthesis of anticancer agents with multitarget mechanism of action. It Is common knowledge that cancer is a multifactorial disease in which genetic modifications ultimately leading to uncontrolled cell growth, metastasis, ability to escape from apoptosis and to survive in hypoxic

conditions. The disorder can originate and spread in different tissues developing various types of tumour, which share these unique characteristics. In this respect, drugs able to simultaneously hit more than one single target could represent a valid alternative to drug cocktails being more effective than a classic monotherapy. Thus, several libraries of compounds having an indolinone scaffold have been successfully designed and synthesized. These new indolinone based molecules exhibited a potent and selective dual inhibition ability towards human carbonic anhydrase IX, XII, and share some of the pharmacophoric features of approved kinase inhibitors. Both hCA and kinases are validated targets for the control of cancer progression. Furthermore, the indolinone is considered a privileged scaffold in medicinal chemistry, being a structural motif in a number of approved drugs, most of which are anticancer agents.

Part of this project was carried out at the University College Cork, in Ireland, under the supervision of Dr. Florence McCarthy. Additionally, considering the current emergency scenario brought on by COVID-19, Daniela participated to another project aimed to the development of SARS CoV 2 non-structural proteins inhibitors.



PhD programme in Philological and Literary, Historical and Cultural Studies

Coordinator: Mauro Pala
Vice-coordinator: Tiziana Pontillo

The PhD Programme in **Philological and Literary, Historical and Cultural Studies** aims at contributing to the post-graduate training of young scholars at the start of their career, enabling them to gain autonomy in the use of philological and hermeneutic disciplinary tools for the analysis of literary sources. The latter will not only be examined in terms of their textual aspects and the relevant critical-literary implications, but will also be considered as documentary evidence that allows the historical reconstruction of the period to which they belong. Comparative research is the preferred approach for the scientific inquiries and the use of philological, linguistic and historical reconstructive skills is strongly encouraged. This programme has a marked international characterisation, stemming from a constant cultural exchange and dialogue between schools of studies of different orientations in the literary, linguistic, anthropological, historical and artistic fields.

On the one hand, it involves study and research activity applied to the philological, linguistic and literary analysis of ancient and medieval sources with an exegetical purpose, but also with the aim of reconstructing their historical, social and philosophical content (**Antiquity and Middle Age Curriculum**). This Curriculum

encompasses the following disciplines: Classical Philology, Early Christian Literature, Greek History, Greek Language and Literature, Latin Language and Literature, Romance Philology, and Sanskrit Language and Literature

On the other hand, it focuses on the developments - and interactions - of European and American, post-colonial literatures and cultures, which are approached from a theoretical-formal point of view and in their socio-historical perspective. Against the background of modernity, the course aims to offer advanced critical tools of philological-textual analysis, which combine the constitution of literary traditions with their cultural contexts (**Modern and contemporary Contexts Curriculum**). This Curriculum includes Anglo-American Literature, Comparative Literature, English Literature, French Literature, German Literature, Hispanic-American Language and Literature, History of Drama and Entertainment, Italian Literature, and Spanish Literature.

An alternative perspective on 17th century Quaker women's self-writings

Ivana Ledda

While attending this Ph.D., I participated as a speaker at various conferences hosted by the University of Cagliari, the British Institute of Florence and the University of Padua, and I published several papers. Thanks to the initiative of my supervisor Prof. Maria Grazia Dongu, I was given the opportunity to discuss part of my research at the 2021 Seminar on English and American Studies at the University of Cagliari (February 2021). My second tutor, Prof. Ben Pink Dandelion, invited me to present a paper about the theoretical aspects of my thesis at the CRQS Student Day in Leeds (April 2022).

I was granted a Globusdoc scholarship in 2022, thanks to which I was able to conduct research at the British Library and at the Friends House Library in London. I have recently become a member of the QSRA (Quaker Studies Research Association) and I have attended courses organised by the Centre for Research in Quaker Studies (University of Birmingham).

The title of my thesis is *Reconsidering the Concept of Early Modern English Autobiography. Quaker Women's Self-Writings in 17th-Century England.* I am studying a small set of spiritual self-writings published by early Quaker women and men over a 50-year period (1650s-1690s), investigating which theoretical approach may serve as the best way to understand the phenomenon of self-writing in its development over time. I am particularly interested in exploring if early Quaker women's spiritual self-writings may be considered either expressions of a dis-

tinct literary culture or as reinterpretations of the mainstream Quaker male culture.

The research I have conducted so far has pointed out that there is a need to reconsider collaborative authorship in early Quaker women's autobiographical texts, especially in light of their relationship with contemporary Quaker men leaders' autobiographical writings. I am investigating this relationship with the help of a hybrid methodological approach, drawing on a range of theoretical frameworks. This approach is allowing me to look at early Quaker self- writings in all their complexity, shedding further light on the commonalities and differences between early Quaker women and men's literary styles.

In particular, Jurij Lotman's semiotics of culture, which focuses on the conceptualisation of culture as a living organism, opens up novel perspectives on the cohesive function of the autobiographical product – in other words, its educational role as an exemplary model to be followed and replicated by the readers in both life and its rewriting. In light of Lotman's contribution, early modern Quaker autobiographical texts can be seen as both mechanisms of individual as well as collective self-organisation – namely, as crucial elements for the creation and perpetuation of the Quaker identity.

Thus, Quaker women's self-narratives play a fundamental role in creating a shared space where the authors are able to interact with both their contemporaries and the next generations, especially encouraging young women to perceive themselves as valuable members of the movement and to write about their spiritual experiences. From this perspective, women's autobiographical texts act as normalising mechanisms that change women's self-perception not only as individuals but as part of a group, stimulating communication with one another and laying the basis for the creation of a distinctive yet inclusive literary and cultural space.

Language Desire and Action: An analysis of Sanskrit philosophy of language and action from 9th century AD.

Sudipta Munsi

Sudipta Munsi (b. 1987) obtained his BA (with an honours in History) and MA (specialising in the social and economic history of early medieval India) in History respectively from University of Calcutta and Netaji Subhas Open University, both located in India. He also took 1 yr. Certificate and Diploma Courses in Sanskrit from Jadavpur University, India, followed by a bachelor degree in Education from Ramakrishna Mission Siksanamandira, an autonomous college of teacher education affiliated to University of Calcutta. Besides, he received traditional training in Sanskrit philosophy and grammar from traditional Indian scholars of Sanskrit at different seats of traditional Sanskrit learning in India like Calcutta, Varanasi and Chennai. Before joining the International Ph.D. program (XXXV Cycle) in "Philological and Literary, Historical and Cultural Studies" at the University of Cagliari, he worked as a Scientific Collaboration in a funded interdisciplinary research project about deontic logic in Sanskrit ritual hermeneutical texts, jointly hosted by the Technical University of Vienna and Austrian Academy of Sciences, Vienna.

His Ph.D. thesis entitled *Bhaṭṭa Jayanta on Sentence Meaning: A Study in the second half of the 5th book of Nyāyamañjarī*, aims at analysing why a rational human being undertakes an action on hearing an exhortative statement in general and the Vedic injunctions in particular. For this, it draws upon the second half of the fifth book of the Sanskrit work, *Nyāyamañjarī*, written by the 9th century AD Kashmiri intellectual, Bhaṭṭa

Jayanta. This text dialectically discusses rival views on instigation like those upheld by Bādari, Kumārila Bhaṭṭa and Prabhākara Miśra and their respective followers. An understanding of these views has immense bearings on issues like the connection between language and reality; the validity of sacred texts; whether or not sacred texts can instigate us independently of any consideration for the result; the difference between agency and eligibility and how they affect interpretations of causality. Hence an attempt has been made to explore the specificities of Jayanta's own view in this regard by comparing it with those of his rivals explicitly mentioned and implicitly embedded in this part of *Nyāyamañjarī*. A comparative assessment of the views of Jayanta and his opponents about how and under what conditions a person undertakes a particular action has also been attempted, by means of which, it has been endeavoured to underline the real merits of Jayanta's theory of human motivation.

His research was supervised by Prof. Elisa Freschi and Prof. Tiziana Pontillo, whose guidance helped him focus on the scientific look and outlook of his research. During his Study Abroad period, he worked under Dr. Hugo David of the French Institute of Pondicherry, India (1st September 2021-30th November 2021), Mm. Dr. R. Mani Dravid Śāstrī of the Madras Sanskrit College, Chennai, Tamil Nadu, India (1st December 2021 – 28th February 2022) and Prof. Lalit Kumar Tripathi of the Central Sanskrit University, Ganga Nath Jha Campus, Prayagraj, Uttar Pradesh, India (1st March 2022 – 3rd June 2022), in course of which he was able to combine his traditional Sanskrit learning with Western scientific research approach.

Munsi, S. Killing Ritually and Beyond. In: Poddighe E, Pontillo T. *Resisting and Justifying Changes II: Testifying and legitimizing innovation in India and Ancient Greek Culture. Supplement to Studi Classici e Orientali*. Pisa: Pisa University Press. 2023 (*forthcoming*).

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Roberta Leu, Monica Carta, Stefania Angioni, and Filippo Frau, for their tireless and pivotal contributions. Finally, this book also offers the opportunity to thank all the people who have contributed to our doctoral programs such as thesis reviewers and members of the exam commitees

This volume reports, in brief, the experien- ce of the students enrolled in the XXXV cycle of the PhD courses at the University of Cagliari. The contributions are grouped by course and are preceded by a presentation of the coordinators of each PhD program. In two pages each student gives the reader an idea of his/her personal experience and of the results of his/her research.

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