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UniCA PhD Book XXXIV Cycle

edited by
Paolo Ruggerone and Vittorio Pelligra



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UniCa PhD Book – XXXIV Cycle
edited by Paolo Ruggerone and Vittorio Pelligra

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Giorgio Ghiglieri
(1962-2021)

In memoriam

INDEX

XIII Introduction of the Rector and Vice-rector
Francesco Mola, Gianni Fenu

3 PhD programme in *Chemical Science and Technology*,
Coordinator: Stefano Enzo
Vice-coordinator: Carla Cannas

3: Synthesis and characterisation of “lead free” piezoceramics, *Antonio Iacomini*;
5: Isolation, chemical and biological characterization of natural extracts,
Antonella Ibba; 7: Metal complexes of environmental and biological interest,
Sebastiano Masuri; 9: Synthesis and Characterization of MOFs for Sensing and
Molecular Spintronics, *Noemi Monni*; 11: Investigation into optical performances
of boron-nitride-based systems, *Junkai Ren*; 13: Synthesis and computational
study on compounds of biological interest, *Federico Riu*; 17: Biofuels from
biocatalysis: the importance of enzyme immobilization, *Davide Tocco*

19 PhD programme in *Earth and Environmental Sciences and
Technologies*
Coordinator: Giorgio Ghiglieri

21: The relationships of bryophytes and orchids with environmental pollution,
Antonio De Agostini; 23: Deep-seated gravitational slope deformation in
central Sardinia: Insights into the geomorphological evolution. Innovative
survey and monitoring techniques, *Valentino Demurtas*; 25: Valorisation of
wet residues through hydrothermal carbonization process, *Gianluigi Farru*;
27: Characterization of fine and ultrafine particles in different exposure
scenarios, *Gabriele Marcias*; 29: Conversion of plant wastes into products of
cosmeceutical and nutraceutical interest, *Matteo Perra*; 31: Bioremediation of
multi-contaminated groundwater using advanced systems, *Giulia Puggioni*;
33: Study of mineralurgical processes for the treatment of mining waste, *Giulio
Sogos*

- 35 PhD programme in *History, Cultural Heritage and International Studies*
 Coordinator: Cecilia Tasca
 Vice-coordinators: Mariangela Rapetti, Christian Rossi
 37: Cinema and Video Games: Rethinking Film Education, *Massimo Atzori*; 39: “For a total regeneration of the island”: Il Partito sardo d’azione and its political and organizational recovery (1943-1969), *Stella Barbarossa*; 41: Sacred Harp: the many dimensions of a glocal singing community, *Delia Dattilo*; 43: Implications of Brexit in the international economic context, *Piotr Dariusz Grabara*; 45: The narration of the Risorgimento in the regional newspapers: a digital public history project, *Erica Luciano*; 47: Women’s memories of Oudlājān: From a communitarian neighbourhood to a placeless city, *Monica Mereu*; 49: Hospitality: a central concept for a paradigm of ‘mobilities’, *Gaspere Messana*; 51: The Jewish community of Istanbul suspended between Erdoğan and Aliyah, *Alessandro Porrà*
- 53 PhD programme in *Civil Engineering and Architecture*
 Coordinator: Ivan Blečić; Vice-coordinator: Roberto Deidda
 55: Digital games and interactive storytelling for cultural heritage, *Sara Cuccu*; 57: Hydrogeological risk reduction measures in response to climate change, *Stefano Farris*; 59: Planning the regeneration of disposed public real estate, *Alessio Floris*; 61: The reuse of former psychiatric hospitals. A methodological model on design, memory and empathy, *Claudia Pintor*; 63: Highly directive nonlinear micro-structured mechanical system, *Anar Rakhimzhanova*; 65: Women, spaces, power. A nomadic approach to read the urban space, *Alice Salimbeni*; 67: Seaplane stations and historical airfields. Towards possible enhancement and reuse, *Monica Vargiu*
- 69 PhD programme in *Electronic and Computer Engineering*
 Coordinator: Alessandro Giua
 71: Electric energy storage systems for the dispatching of renewable sources, *Daniele Battaglia*; 73: Malware analysis and detection in personal devices and networks, *Fabrizio Cara*; 75: Non-standard operators for CNN HW accelerators on FPGA, *Marco Carreras*; 77: Cyber security of Discrete Event Systems, *Chao Gao*; 79: Non-blockingness verification and supervisory control of Petri nets, *Chao Gu*; 81: Verification and Application of Detectability based on Petri Nets, *Hao Lan*; 83: RF modeling, design, characterization, and biomedical applications of magnetic scaffolds, *Matteo Bruno Lodi*; 85: Towards Debugging and Improving Adversarial Robustness Evaluations, *Maura Pintor*; 87: Coordination of open multi-agent systems, *Zohreh Al Zahra Sanai Dashti*; 89: Runtime adaptive cognitive IoT nodes for healthcare monitoring, *Matteo Antonio Scrugli*; 91: Data traffic analysis to monitor and understand the people’s mobility in Smart Cities, *Marco Uras*

- 93 PhD programme in *Industrial Engineering*
Coordinator: Francesco Aymerich
95: Numerical and experimental analysis of OWC systems with Wells turbine, *Fabio Licheri*; 97: Structural health monitoring & damage detection in composite materials, *Gabriela Loi*; 99: Analytical model for GaN HEMTs in high frequency / high voltage applications, *Paolo Pirino*; 101: Development of an integrated ICT platform for municipal waste management, *Aiman Rashid*; 103: Optimization-based monitoring in Power Systems, *Antonio Vincenzo Solinas*; 105: Robust Optimization of Aeronautical Components, *Irene Virdis*
- 107 PhD programme in *Mathematics and Computer Science*
Coordinator: Michele Marchesi
Vice-coordinator: Roberto Tonelli
109: Machine Learning & Deep Learning approaches applied to financial forecasting and robo-trading, *Andrea Corrigan*; 111: Predictive analytics models and tools for decision support of stakeholders in digital agriculture, *Francesca Maridina Mallocci*; 113: Software engineering techniques and automatic generation of dApps, *Lodovica Marchesi*; 115: On the computation of the minimal-norm solution, *Federica Pes*; 117: Generalized Adaptive Refinement for Grid-based Hexahedral Meshing, *Luca Pitzalis*; 119: Machine Learning powered financial forecasting for statistical arbitrage, *Maria Madalina Stanciu*; 121: Financial time series forecasting using traditional econometrics methods and Artificial Intelligence algorithms, *Nicola Uras*
- 123 PhD programme in *Molecular and Translational Medicine*
Coordinator: Sebastiano Banni
125: Angiogenic profile variation in cancer patients receiving anti-angiogenics, *Eleonora Lai*; 127: Novel biomarker for the diagnosis of neurodegenerative disease, *Elias Manca*; 129: Thyroid Hormone in Hepatocellular Carcinoma, *Rajesh Pal*; 131: Gut microbiome analysis in metabolic, neurological, and inflammatory disorders, *Vanessa Palmas*; 133: Metabolomic alterations and dependencies in colorectal cancer cells, *Martina Spada*
- 135 PhD programme in *Neuroscience*
Coordinator: Paola Fadda
137: Effects of antiepileptic therapies on neuronal plasticity, *Roberta Coa*; 139: Neurosteroids in Parkinson's disease, *Sara Corsi*; 141: Taste and smell physiological mechanisms and their health implications, *Mariano Mastinu*; 143: Cerebral white matter status and resting state functional MRI, *Michele Porcu*; 145: Investigation on maternal immune activation rat model of schizophrenia; *Michele Santoni*

- 147 PhD programme in *Philosophy, Epistemology, Human Sciences*
Coordinator: Giuseppe Sergioli
149: Adam Smith on Human Nature and the Self, *Riccardo Bonfiglioli*; 151: Artistic metaphors and storytelling in Sardinia, *Alice Guerrieri*; 153: Emotion and deduction, *Lucrezia Pelizzon*; 155: Professional development between critical pedagogy's theory and educational practices, *Andrea Spano*; 157: Mathematics and the Pythagorean apocrypha, *Matteo Varoli*
- 159 PhD programme in *Physics*
Coordinator: Paolo Ruggerone
Vice-coordinator: Umberto D'Alesio
161: Highly efficient warm white emission from lead free halide double perovskite, *Fang Liu*; 163: HI survey of the Fornax galaxy cluster, *Alessandro Loni*; 165: Pixel chamber: a solid-state bubble chamber for imaging of charm and beauty, *Alice Mulliri*; 167: CP-violation measurements at LHCb, *Piera Muzzetto*; 169: Dark matter and neutrino physics at low-energy scale, *Emmanuele Picciau*; 171: Structural and optical characterisation of all-inorganic perovskites, *Jessica Satta*; 173: Spin and transverse momentum dependent fragmentation function and their role in hadron production, *Marco Zaccheddu*
- 175 PhD programme in *Economics and Business*
Coordinator: Vittorio Pelligra
177: Statistical methods for assessing the impact of military presence in Sardinia, *Rossella Atzori*; 179: The analysis of ordinal data through distance-based approaches and matched pairs models, *Alessio Baldassarre*; 181: ML Models to Classify Social Media Sentiment and Predict Stock Trends, *Giacomo Camba*; 183: Electricity market and renewable energy production, *Laura Casula*; 185: The future of tourism sector. Environmental education for tourist children, *Marta Fundoni*; 187: Luxury goods market. Analysis of the driving forces behind consumers' purchase intention in the context of Persian Luxury hand-woven carpets, *Parichehr Yarahmadi Dehnavi*; 189: Eye tracking and sentiment analysis to evaluate user behavior and opinions, *Gianpaolo Zammarchi*
- 191 PhD programme in *Legal Sciences*
Coordinator: Gianmario Demuro
Vice-coordinator: Silvia Corso
193: Conscientious objection and right to abortion, *Stefania Flore*; 195: The right to therapeutic self-determination in the end of life choices, *Alessandra Leuzzi*; 197: The difficult interaction between political power and globalized economic power, *Lorenzo Moroni*

- 199 PhD programme in *Innovation Sciences and Technologies*
 Coordinator: Roberto Orrù
 201: Home-based EXergames To impRove cognitivE function in Multiple Sclerosis, *Letizia Castelli*; 203: Analysis and screening of microalgal strains for advanced biotechnological applications, *Giacomo Fais*; 205: Characterisation of cardiac functions with imaging in healthy populations, *Sara Magnani*; 207: Fabrication strategies of noble and non-noble nanoporous metals, *Andrea Pinna*; 209: Evaluation of beach-cast litter influence on coastal morphodynamics, *Daniele Trogu*
- 211 PhD programme in *Life, Environmental and Drug Sciences*
 Coordinator: Simona Distinto
 Vice-coordinator: Enzo Tramontano
 213: Delivery of a corticosteroidal nanosuspension via electronic cigarette, *Luca Casula*; 215: Different proteomic approaches on saliva of Alzheimer's disease subjects, *Cristina Contini*; 217: Reproductive biology and ecology of the sea cucumber *Holothuria tubulosa*, *Viviana Pasquini*; 219: Exploring the pharmaceutical profile of furobenzopyrone derivatives, *Lisa Sequeira*
- 221 PhD programme in *Philological and Literary, Historical and Cultural Studies*
 Coordinator: Mauro Pala
 Vice-coordinator: Tiziana Pontillo
 223: A Study of the homometric occurrences in ancient Greek strophic poetry, *Alessio Faedda*; 225: Ancient language and modern literature, *Marta Karcz*; 227: A new milestone in the medieval visionary literature of allegorical voyages, *Andrea Macciò*; 229: The revision of the Neoliberal concept of human nature in the science fictional Utopias of 1970s, *Francesco Nieddu*
- 231 Index of names

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 even in such difficult times caused by the COVID19 emergency. 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. We hope this cultural achievement may continue in the future:

An important remark: the volume is dedicated to Prof. Giorgio Ghiglieri, the coordinator of the PhD course in Earth and Environmental Sciences and Technologies, who died in August 2021. He was a very engaged coordinator, and his energy and attitude were a source of ideas and suggestions always associated with a smile. We miss Giorgio very much.

Francesco Mola
Rector of the University of Cagliari

Gianni Fenu
Vice-rector of the University of Cagliari



Dottorato in Scienze e Tecnologie Chimiche

PhD programme in Chemical Science and Technology

Coordinator: Stefano Enzo

Vice-coordinator: Carla Cannas

The PhD in Chemical Science and Technology is the only PhD course in Chemistry in Sardinia, and since 2013-2014 it involves the universities of Cagliari (UNICA) and Sassari (UNISS) with a joint Agreement. It was established with the aim of training highly qualified young scientists in the chemistry issues throughout science and research, by giving an opportunity to young Italian and foreigner master-degree level candidates to plan and carry out a research project in the most advanced issues of chemical science and technology. To this end the selected PhD students are accompanied and supported with a continuous experimental activity sustained by a tailored teaching path. The Board offers to the PhD students the possibility to interact with institutions, industries, and scientists active in the national and international panorama, to spend a period in selected international laboratories and to participate to conferences, workshops and summer schools. The XXXIV cycle stands on 7 PhD students, 3 supported by UNICA, 3 by UNISS and 1 more by MIUR (PON-RI Program), the majority having applied for the additional Doctor Europaeus title. Among them one student is coming from China and a cotutelle is active with Valencia. During the last years (2018-2021) other foreign students coming from India, Hungary and South Africa have been hosted. Several agreements were

established and activated for cotutelle with various universities like Cordoba, La Roja, Angers, Barcelona, Valencia. It should also be acknowledged that three PhD students have been awarded as the best PhD thesis at National Chemistry Congresses and one for poster presentation at an International Conference. At international level we also report the successful participation to DAAD Program for a scholarship at Universität Erlangen-Nürnberg and to Vinci Program to organize an international workshop on advanced materials.

Synthesis and characterisation of “lead free” piezoceramics

Antonio Iacomini



Antonio Iacomini obtained the master's degree cum laude (2017) in Chemical Science at University of Sassari with a thesis entitled “Synthesis and characterisation of “lead free” piezoceramics containing sodium and potassium niobates” under the supervision of prof. Stefano Enzo and dr. Sebastiano Garroni. After graduation he spent four months (December 2017-March 2018) within the European program “Erasmus

Traineeship+” at the Instituto de Ciencia de Materiales de Madrid (ICMM/CSIC) under the supervisor of prof. Lorena Pardo.

During his PhD he continued the study of piezoelectric materials. His research work has focused on the *synthesis and characterisation of a new solid solutions based on sodium and potassium niobate (KNN)*. The first year of the work was dedicated on the synthesis and characterisation of the KNN doped with small amount of bismuth ferrite (BF). In particular, a great effort was dedicated to optimizing the main parameters (milling time and sintering temperatures) involved in the manufacturing process of the ceramic. Moreover, two additives (CuO and Y_2O_3) have been selected to be tested on KNN-BF system in order to improve the sintering process and its effect on KNN-BF system has been investigated in detail.

During this period, he has developed skills in X-Ray diffraction (XRD) e Scanning Electron Microscopy (SEM) characterisation techniques.

He spent 2 months (February – April 2020) at the Instituto de Ciencia de Materiales de Madrid (ICMM/CSIC) under the supervision of prof. Lorena Pardo where he performed the piezoelectric characterisation of the samples prepared during his first year of activity. During

this experience, he acquired skills in the electromechanical characterisation of piezoelectric ceramic by impedance and dielectric spectroscopy. Through a collaboration with the Engineering Department of University of Cagliari he has been able to experiment unconventional and very performing sintering techniques such as Spark Plasma Sintering (SPS) on the compositions under study.

The last part of the thesis was dedicated to the development and prototyping of a device for in situ XRD analysis of piezoceramics during the poling process.

During his PhD he participated in an entrepreneurship and innovation competition called “Contamination Lab Uniss”, winning the first prize with a project called “Ecoflow” dedicated to the removal of microplastics from domestic waste.

He co-organized the international conference “PIEZO2021: Piezoelectrics for End Users XI” in which he also participated with an oral presentation awarded as the “best student oral competition” by the JECS trust organization.

Isolation, chemical and biological characterization of natural extracts

Antonella Ibba



Bachelor's degree in Experimental Biology in 2011 at the University of Cagliari with a thesis on GC/MS analysis of essential oils obtained by means of supercritical CO₂ extraction (SFE) and hydrodistillation. In 2014 I got my master's degree in Cellular and Molecular Biology with a thesis concerning the study of ionic liquids using NMR spectroscopy. I am currently a PhD student in Chemical Sciences and Technologies

of the XXXIV cycle, under the supervision of Prof Silvia Porcedda. Before entering the PhD program, I performed a voluntary post-graduate internship for three years as a Biologist-Researcher trainee in the Molecular Biology, Microbiology and DNA Sequencing Laboratory, at the San Giovanni di Dio hospital (CA), mainly dealing with the antimicrobial activity of substances against human pathogens.

The title of my PhD project is *"Isolation, chemical and biological characterization of extracts, obtained from plant species of the Rosaceae family"*. This project aims at obtaining and chemically characterize natural extracts showing antimicrobial properties against human pathogens resistant to antibiotics. The increase in the antibiotic resistance of pathogenic microorganisms is increasingly and dramatically evident. The study of the antimicrobial activity of natural extracts could contribute to the discovery of new strategies to support antimicrobial therapies and the identification of bioactive compounds (or class of compounds) extracted from plants and useful for the design of antibiotic drugs or the preparation of toothpastes, mouthwashes, and disinfectants. The multidisciplinary of my project has allowed me to apply, in addition to the chemical study, also various biological assays (DSC-UniCA Prof Germano Orrù, DSA-UniCA Prof. Antonella Fais and Dr. Benedet-

ta Era) including the use of the antibiogram method, to evaluate the antimicrobial activity, the spectrophotometric evaluation of the antioxidant activity of phenols and the enzymatic activity with respect to xanthine oxidase. The investigation of my research focused mainly on the extracts that I obtained from *Rosa canina* and *Rubus ulmifolius*. In particular, since an extract obtained from *R. canina* seeds showed a very high antimicrobial activity against numerous human pathogens, on 22 December 2020 the inventors Alessandra Piras, Antonella Ibba, Germano Orrù and Silvia Porcedda filed an international patent application in the state of concession and ownership of UniCa. The study of the extracts obtained from the leaves of *R. ulmifolius* made it possible to isolate – by extraction with supercritical CO₂ or organic solvents – antimicrobial mixtures active against pathogens of the oral cavity.

In collaboration with Dr. Antonella Rosa at the DSB-UniCa, I was able to perform the qualitative-quantitative analyses by HPLC equipped with a Diode-Array Detector and an Evaporative Light Scattering Detector (HPLC-DAD / ELSD) of the fixed oils obtained from the *R. ulmifolius* matrix. The results of this study showed the nutritional properties of the fruit extracts, obtained by SFE and Soxhlet apparatus with *n*-hexane, thanks to their content of essential fatty acids.

In collaboration with Prof. Enzo Cadoni and Prof. Tiziana Pivetta at DSCG-UniCa, the qualitative analysis performed by low- and high-resolution spectrometry allowed me to identify different classes of biological compounds: phenols, lipids, and carbohydrates.

Ibba A., *et al.*, Fatty acid profile and antimicrobial activity of *Rubus ulmifolius* Schott extracts against cariogenic bacterium *Streptococcus mutans*, *Biointerface Research in Applied Chemistry* 12: 25-33 (2021)

Metal complexes of environmental and biological interest

Sebastiano Masuri



Sebastiano Masuri was born in Nuoro in 1993. He graduated in Chemistry (BSc) at UNICA in 2015 (cum laude) under the supervision of Prof. Enzo Cadoni and Dr. Nicoletta Curreli. He then got his Master's in Chemical Science at UNICA in 2018 (cum laude) under the guidance of Prof. Tiziana Pivetta and Dr. Maria Grazia Cabiddu. After his MSc, he won an "Erasmus+ for traineeship" grant, which gave him the chance to spend three months (May-July 2018) at Selvita SA in Krakow, where he interned as organic/medicinal chemist. He won a PhD scholarship (POR-FSE) in November 2018, and he has been attending since then the PhD course in "Chemical Science and Technologies" (UNISS/UNICA) under the supervision of Prof. Tiziana Pivetta. Sebastiano has currently published three papers in international peer-reviewed journals and one book chapter.

He has focused his activity towards two different research topics: *i)* synthesis of novel bioactive ligands and Copper(II) complexes; *ii)* synthesis of novel fluorescent chemosensors for the recognition of metal ions of environmental and biological interest. As regards the first research line, he has synthesized and characterized a series of Copper(II) metal complexes as potential novel anticancer drugs. The choice of focusing towards this application is related to the high incidence of cancer in our society, along with the need of finding novel anticancer drugs that are active towards cisplatin-based resistant cancer cells and/or with a better toxicological profile compared to currently approved anticancer drugs (mainly based on Platinum(II)). The anticancer properties of the synthesized compounds have been evaluated in collaboration with the research group of Prof. Petr Vaňhara (Masaryk

University, Brno). These studies have shown how these compounds possess high potency (*in-vitro*) towards ovarian cancer cells and exerts their activity by interfering at the Endoplasmic Reticulum (ER) level. Additional studies aimed at having more insights about the transport and molecular mechanism of these potential drugs are currently ongoing. Sebastiano has also synthesized a family of coumarin-based molecules having potent antioxidant and lipoxygenase inhibitory activity. He has evaluated the biological properties of these compounds by combining several experimental and computational techniques. Lipoxygenases constitute a widespread class of enzymes, which are involved in the biosynthesis of leukotrienes that are known to act as chemical mediators of several inflammatory and allergic phenomena (e.g. asthma, psoriasis and rheumatoid arthritis), but are also believed to be involved in the pathogenesis of several types of cancers.

As regards the second research line, he has synthesized and studied the fluorescence properties of a family of coumarin-based ligands, finding out that these molecules are able to interact selectively with Iron(III) by modifying their fluorescent emission properties, exhibiting a so-called “ratiometric and TURN-ON” mechanism towards this metal ion. The most promising molecule of the series have been subjected to further studies, and based on these findings, has been proposed as potential fluorescent probe for the detection of Iron(III) in solution at low concentrations (micromolar level). Iron(III) detection is extremely important because of its role as cofactor in biological systems, but also for environmental applications, such as steel industry pollution evaluation.

All these findings will be reported in the PhD thesis “*Metal complexes of environmental and biological interest*”.

Masuri S., *et al.*, The first copper (II) complex with 1,10-phenanthroline and salubrinal with interesting biochemical properties, *Metallomics* 12: 891-901 (2020)

Synthesis and Characterization of MOFs for Sensing and Molecular Spintronics

Noemi Monni



Noemi Monni (N.M.) graduated with honors in Chemical Sciences (M. Sc.) in 2017, at University of Cagliari, after an exchange period at the University of Angers, under the supervision of Dr. Narcis Avarvari. Then she worked as a research fellow at the Molecular Materials Lab, headed by prof. Maria Laura Mercuri, Dipartimento di Scienze Chimica e Geologiche, University of Cagliari, for 8 months. In 2018, she won a grant funded by the European Action COST MOLSPIN, for a research stay at Insitute of Molecular Science (ICMol), University of Valencia, under the supervision of prof. Eugenio Coronado and prof. Miguel Clemente-León. Then she started her PhD as a co-joint thesis between UniSS-UniCA School (Chemical Sciencies and Technologies) and University of Valencia (Nanoscience and Nanotechnology), under the supervision of Proffs. Maria Laura Mercuri, Enzo Cadoni and Prof. Miguel Clemente-León.

Her PhD thesis, entitled *"Synthesis and Characterization of Metal-Organic Frameworks (MOFs) for Sensing and Molecular Spintronics"*, is focused on the design, synthesis, and characterization of multifunctional molecular materials for technological applications. Molecular materials, namely materials built from molecular building blocks, are the best candidates because their chemical and physical properties can be finely tuned by a careful choice of their molecular building blocks. Recently, among molecular materials, Metal-Organic Frameworks (MOFs), has shown ever-growing interest in Material Science. MOFs are versatile networks composed by organic molecules (*linkers*) and metal ions (*nodes*) which form, through a self-assembly mechanism, porous structures. Due to their chemical and physical characteristics they have a

huge potential in a plethora of applications such as gas storage and separation, catalysis, sensing, information storage etc. In this context, N.M. PhD thesis has been devoted to the design and synthesis of *i*) novel bidimensional (2D) and tridimensional (3D) magnetic MOFs, mainly based on Lanthanide ions with large magnetic anisotropy, *i.e.*, Dy^{III}; *ii*) novel 3D luminescent MOFs based on NIR emitting Lanthanides, *i.e.* Nd^{III} and Yb^{III}.

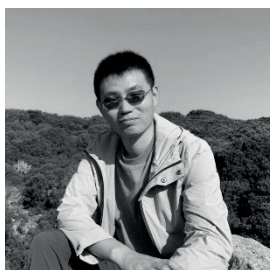
As for magnetic MOFs, it has been observed that Dy^{III} shows great affinity for benzoquinone-based linkers and when combined with the heterosubstituted anilate 3-chloro-6-cyano-2,5-dihydroxybenzo quinone, four different types of 2D MOFs, are afforded, showing frequency-dependent magnetic behavior and polymorphism[1]. Instead, by using the novel triazolyl-substituted anilate linker, 3D MOFs showing Single-Ion Magnet behavior have been obtained, paving the way to the use of anilate-based MOFs in molecular spintronics as data storage systems.

Regarding luminescent MOFs instead, the final aim is to detect temperature in biological tissues, in the 293-313K physiological range, thus the trimesic acid, a biofriendly linker, was combined with Nd^{III} and Yb^{III} in different stoichiometric ratios, to give rise to 3D luminescent MOFs. These materials, where Nd^{III} and Yb^{III} are simultaneously presents, act as ratiometric thermometers, where a change of their NIR luminescence intensity *vs* temperature is observed. Biological tests on these systems are in progress to evaluate their capability to be internalized in cells, for testing their performance as thermometers in biological systems.

Sahadevan S.A., *et al.*, Dysprosium Chlorocynoanilate-Based 2D-Layered Coordination Polymers, *Inorganic Chemistry* 58(20): 13988–13998 (2019)

Investigation into optical performances of boron-nitride-based systems

Junkai Ren



Junkai Ren is a PhD student of Chemical Sciences and Technologies in University of Sassari (Supervisor Prof. Plinio Innocenzi), in consortium with the University of Cagliari (Coordinator Prof. Stefano Enzo). He obtained a Bachelor's Degree of Engineering in Material Forming & Control Engineering at Changsha University of Science and Technology (Changsha, China) in 2015. He received a Master's Degree of Natural

Science in Chemistry and Physics of Polymer at University of Chinese Academy of Sciences (Beijing, China) in 2018.

Presently, he works as a full-time research student at the Laboratory of Materials Science and Nanotechnologies (LMNT) with a PhD project focused on *optical performances of boron-nitride-based systems*. Briefly, hexagonal boron nitride (h-BN) is a two-dimensional (2D) material in the spotlight since the isolation of graphene. The wide bandgap (E_g), around 6 eV, has attracted much attention because of the potential applications in photonics and optoelectronics. The photoluminescent properties of h-BN systems have been mainly attributed to the presence of defect states, including boron/nitrogen vacancies, carbene structure, and oxygen-doping. However, the simultaneous presence of specific impurities or heterogeneous distribution of defects has made the comprehension of their fluorescence properties a challenging task.

Therefore, a defect-controlled method is necessary to prepare and investigate fluorescent BN nanomaterials including nanosheets and nanodots. Both top-down and bottom-up approaches allow producing high-quality BNs. For example, sonication can make them exfoliated from bulk crystals down to nanosheets; hydrothermal route can produce BN nanodots from molecular precursors. Subsequently, coupled

with thermal oxidation treatments, a combination of different analytical techniques such as XPS, XRD, TEM, UV–Vis, TGA-DTA and fluorescence can be used to characterize the possible correlation between the present defects and the corresponding emissive features. In addition, quantum chemical calculations have been an important support to corroborate the experimental findings.

Ren J., *et al.*, Defect-assisted photoluminescence in hexagonal boron nitride nanosheets, *2D Materials* 7: 045023 (2020)

Synthesis and computational study on compounds of biological interest

Federico Riu



In 2017 I graduated in Pharmaceutical Chemistry and Technologies at University of Sassari. In 2018 I started my PhD program in Chemical Sciences and Technologies at University of Sassari. In 2020, I joined prof. Göran Widmalm's group as exchange PhD student at Department of Organic Chemistry, Stockholm University (SU). My PhD program is mainly focused on the synthesis of new compounds of biological interest. Now I'm currently in Stockholm, where my work is focused on computational approaches to fragment-based drug discovery and synthesis of oligosaccharides.

My PhD program was divided between University of Sassari and Department of Organic Chemistry at Stockholm University in Sweden. During these three years I have had the opportunity to expand my knowledge in the field of Medicinal Chemistry, in all its facets. In Italy, I focused on the synthesis of molecules, "small molecules", which could show a biological activity, in particular an antitumor activity. Through computational (design) and experimental approaches, between chemical synthesis and biological evaluation, it was possible to create a series of molecules with an antitumor activity, clarifying their mechanism of action as inhibitors of mitosis (cell division). Given the interest in these molecules, it was possible to create a new series of structural analogues of the first series of molecules, now under biological evaluation. During the second year, I started my PhD traineeship in Stockholm at Department of Organic Chemistry in Göran Widmalm's group. During this period, I was able to interface with a different approach to research, but with the awareness of continuing PhD during COVID-19 pandemic situation. In this regard, I am grateful for having

participated in the production of “hand sanitizer” at the Department in Stockholm, to be donated to some Swedish hospitals. Regarding the research point of view, I initially focused on a computational approach (docking and molecular dynamics studies) to the design of new molecules of bio-organic interest. In particular, my interest is focused on the study of the polar / nonpolar interactions of a molecule in the binding pocket of a protein / enzyme. In the second part of my period (still in progress) I am involved in the synthesis of oligosaccharides of biological interest, as they are analogues of sugar building blocks already found in various bacteria, such as *Aeromonas salmonicida*.

Piras S., *et al.*, Synthesis, antitumor and antiviral in vitro activities of new benzotriazole-dicarboxamide derivatives, *Front Chem* 9: 660424 (2021)

Biofuels from biocatalysis: the importance of enzyme immobilization

Davide Tocco



Davide Tocco graduated at University of Cagliari-Italy (MSc cum laude) in 2018. He has been Erasmus student at University of Limerick (Ireland 02/2018 – 07/2018). In 2019, He won a Ph.D. Scholarship PON-Cycle XXXIV (2019-2021) with a project entitled “*Biofuels from biocatalysis: the importance of enzyme immobilization*” in collaboration with the Friedrich-Alexander-Universität Erlangen-

Nürnberg (Germany) and with DP-Lubrificanti Spa (Aprilia). He was awarded a DAAD Scholarship, and he spent a research period at Universität Erlangen-Nürnberg (01/10/2020 – 31/05/2021) to develop new materials for the enzyme immobilisation.

His research focuses on the use of enzymes involved in processes to turn biomass in biofuels, in particular Lipases to produce biodiesel from exhaust oils and fungal Laccases for delignification of lignocellulosic biomass (LBM) to obtain cellulose. The use of free enzymes is often hampered by several limitations such as: high costs, low operational stability (extreme conditions of T and pH) and difficult in recovery and reuse making them not suitable for industrial processes. Most of these problems can be overcome through enzyme immobilisation. The enzymatic activity and stability depend on the choice of the support as well as on the method used for the enzyme immobilization. During his research, the ligninolytic enzymes have been immobilised on different supports such as: Metal Organic Frameworks (MOFs) in particular Fe-BTC, Tb-BTC, Gd-BTC, ZIF-zni and Silica material as zeolite MFI-Type Zeolite Crystals with Embedded Macropores to investigate the kinetic parameters (KM and Vmax) of free and immobilised enzymes biocatalysts and both storage and operational stability. The change in

the response helped to understand better the enzyme system to adapt the future choices of supports and immobilization and conditions. The biocatalysts have been characterized by Scanning electron microscopy (SEM) analysis to evaluate the morphological properties of the material. Nitrogen adsorption isotherms will allow to measure the surface area, pore volume and pore size distribution. XRD (X-ray Diffraction) to analyse the phases, the crystallinity of the material. Chemical composition will be determined through thermogravimetric analysis (TGA), whilst spectroscopic characterization will be performed using FTIR.

Tocco D., *et al.*, Recent Developments in the Delignification and Exploitation of Grass Lignocellulosic Biomass, *ACS Sustain Chem Eng* 9: 2412–2432 (2021)



PhD programme in Earth and Environmental Sciences and Technologies

Coordinator: Giorgio Ghiglieri

The cultural core of the PhD training project is represented by a systemic, integrated, interdisciplinary and multi-level approach to the study of the territory as a physical-natural environment and the technologies necessary for its conservation/remediation.

The internationalization of the PhD is done through the involvement of the University of Barcelona and Girona (Spain), as well as through participation in international research programs and projects.

The main topics of the PhD course are the geological knowledge, the management of the physical and biotic environment, georesources, soil and subsoil, ecosystems and vegetal habitats, solid and liquid wastes, contaminated environmental matrices, secondary raw materials. It is worth to underline the connection existing between basic and applied disciplines, and between abiotic and biotic issues, in line with current trends in international research.

The knowledge of the territory and the protection and promotion of the environment are topics considered as a priority at international level, in particular by the European Union and for the Mediterranean area. For Sardinia, the conservation and valorization of the environment is a strategic aspect for the regional economy and for the development of sustainable tourism. The effects of such problems (coastal erosion, hydrogeological imbalances, desertification, pollution, coast-

al area salinisation, eutrophication of the basins, loss of biodiversity, contaminated sites, solid and liquid residues to be managed) result in heavy environmental, and thus socio-economic, imbalances. All these aspects emphasize a strong need for conservation/remediation of the territory, its proper use and rational exploitation of resources.

The PhD course, therefore, has a strong relation with the local territory, while also pursuing research topics of general and basic interest. It offers courses, seminars and summer schools, participation to national and international conferences and training opportunities in Italian and foreign Research Centers.

Participation to conferences and stages is considered as a priority for training and updating purposes.

The achievement of autonomy in research, in particular the capability of publishing on international journals, is considered as a primary objective.

<http://dottorati.unica.it/stta/>

The relationships of bryophytes and orchids with environmental pollution

Antonio De Agostini



Antonio De Agostini graduated in Natural Sciences at the University of Cagliari in February 2017. His Master's degree thesis "*Ophrys annae* and *Ophrys chestermanii*: morphological and ecological analysis. Evolutionary models in conditions of insularity" was focused on orchid reproductive biology. During his studies, he spent 15 months at the University of the Basque Country (Bilbao, Spain), under the Erasmus and

Erasmus+ projects and for part of his PhD. This period abroad allowed him to work with the University of the Basque Country 'EKOFIKO' group, which studies the ecophysiology of stress and contamination in plants. He joined the PhD program of the University of Cagliari in the Earth and Environmental Sciences and Technologies course and his PhD research was conducted in the Botany Section of the Department of Environmental and Life Sciences.

His PhD project is titled *Assessment of the effects of atmospheric and soil contamination on bryophytic and orchidological flora in areas ecologically compromised by anthropogenic activity*. Plants are in fact intimately linked to water, atmosphere, and soil, so that any contamination of these matrices immediately echoes on them. For this reason, plants have been widely used to study environmental pollution both as biomonitors and as biological models. Given this framework, his PhD project addresses the topic of the relationships between environmental pollution and plants, by focusing on two plant groups: bryophytes and orchids. Bryophytes and orchids somehow stand at the antipodes of the evolution of land plants, the first being one of the most ancient plant groups that led land colonization, the latter being a relatively recent *taxon* that is still experiencing an active evolutionary radiation.

Focusing on the two above-mentioned plant groups allowed to compare adaptive strategies that such different and distant plants put in place to face the same ecological challenge: coping with severe abiotic stress in areas compromised by current or past human activity.

In order to better appreciate the strategies developed by the studied *taxa* to face environmental pollution, the PhD focused exclusively on wild populations that naturally thrive in polluted and extreme ecological contexts such as spoil heaps and tailing dumps in abandoned mining areas. As a result, it was observed that also these peculiar sites could host several bryophytes and some orchids, each one of them implementing different strategies to cope with the abiotic stresses linked to the growth context. Studied species (as in De Agostini et al., 2020) were characterized in their morphometry and physiological features, in their interactions with the environment and other organisms and the same interactions with pollutants were described as well. Despite generalized reduced photosynthetic efficiency and biomass production as a consequence of pollutant uptake, the populations under study tolerate environmental pollution and the features of this tolerance are species-specific. In conclusion, a long-standing process of natural selection seems to have guaranteed to some bryophytes and orchids a certain degree of tolerance towards environmental pollution which should hence be exploited to improve the management of abandoned mining areas and to face similar environmental issues.

De Agostini A., *et al.*, Heavy metal tolerance of orchid populations growing on abandoned mine tailings: A case study in Sardinia Island (Italy), *Ecotoxicol Environ Saf* 189: 110018 (2020)

Deep-seated gravitational slope deformation in central Sardinia: Insights into the geomorphological evolution. Innovative survey and monitoring techniques

Valentino Demurtas



Valentino Demurtas was born in Lanusei on the 07rd of December 1992. In December 2017 he graduated with Laude in Geological Science, at the University of Cagliari. From October 2018 he has been a PhD student at the Department of Chemical and Geological Sciences – University of Cagliari. Since he was a student, he has dealt with geological hazard in particular landslides.

He collaborated with foreign research centres during the academic career through internships and research projects (British Geological Survey, Norway geological Survey, University of Svalbard, University of Barcelona, Beijing Geosciences University, Shanghai University).

The PhD research project concerned to the study of Deep-Seated Gravitational Slope Deformations (DSGSDs) in Sardinia. The aim is to identify the areas affected by these processes and understand their geo-structural features and their evolution. These gravitational processes related to the geodynamic evolution of the western Mediterranean in the Pliocene and Quaternary, and in particular with the Uplift processes. A multiscale approach will be used based on the geo-structural and geomorphological analysis of the slopes affected by DSGSDs processes. On a local scale, the study was based on the geological, geomorphological, structural, and geotechnical characterization of the slopes, using also innovative technologies such as drone photogrammetry for high resolution reconstruction of the ground surface. The objectives are to contribute to the knowledge on the DSGSDs obtaining

three-dimensional interpretative models related to the geomorphological and geostructural structure on a local scale and to insert them in the complex geodynamic context of the Mediterranean and active tectonics in Sardinia.

To analyse DSGSDs in different tectonic and climatic context a mapping of landslides in Svalbard archipelagos was carried out, in collaboration with Norway Geological Survey and University of Svalbard. Using remote sensing techniques was analysed DSGSDs in U-Shaped glacial valleys and coasts of the fjords relating them to the climatic, geomorphological, and tectonic features.

In conclusion multi-source and multi-scale monitoring system was built in Ogliastro (Sardinia). Space-borne Interferometric Synthetic Aperture Radar (InSAR) data using ERS and Sentinel-1 satellites identified downslope movement identified as DSGSDs active in the past decades. To better understand the kinematics and short-term deformation of the unstable slopes, a monitoring system, consisting of GNSS antenna, tiltmeter, and extensometer, have been installed along the DSGSDs near urban areas. A distribution of GNSS measurement points in the unstable area and adjacent stable areas have since 2020 provided periodic measurements of the deformation. With a temporal resolution of 30 seconds, extensometers and tiltmeters have been recording changes in large block inclinations and movements over prominent fractures. Historical InSAR displacement rate and monitoring data support the model of rock slope deformation indicating large scale-toppling and deep landslides. 24/7 monitoring system could become an essential component of a for early-warning system.

Valorisation of wet residues through hydrothermal carbonization process

Gianluigi Farru



Gianluigi Farru was born in Cagliari on August 18, 1992. He received his bachelor's degree in Environmental Engineering from the University of Cagliari in 2016 and his Master's degree with honours in Environmental Engineering from the University of Cagliari in 2018 concluding with a thesis on indoor bioaerosol. He is enrolled on the Ph.D. course since 2018. He had been visiting student at IMT-Atlantique, in

Nantes (France) in 2018. In 2020, he had been visiting researcher at Leibniz Institute – ATB, in Potsdam (Germany) where he developed a network of contacts with international researchers and improved his scientific and professional skills. Currently, he is working on his Ph.D. dissertation on the *valorisation of biomasses through the hydrothermal carbonization process*.

In his research, he studied the application of the hydrothermal carbonization process to different wet organic residues. Hydrothermal carbonization (HTC) is an innovative thermochemical process that can convert an organic material into a valuable solid product called hydrochar. It uses subcritical water as reactant and solvent during the process, resulting in an output liquid phase (process water) containing several organic compounds and nutrients. This makes HTC an interesting treatment, especially for wet residues. Many feedstocks were studied such as hemp and digestate from anaerobic digestion of hemp, spent coffee grounds, grape marks, brewing residues, and plastic materials like Covid19 waste and cigarette butts. The aim of the work was to investigate the effects of the process parameters like temperature, holding time, solid load, and feedstock composition on the production and quality of the solid and liquid phase. Moreover, it aims to

find a better destination for these products in order to valorise the initial residues. Several tests were carried out in a pressurised reactor at different temperatures between 180 and 220 °C and holding time from 1 to 6 hours. The output slurry was separated between solid and liquid phases which were deeply characterized. Many properties of hydrochars were improved (higher carbon content, lower ash content, increased higher heating value and better dewaterability) in comparison with their feedstocks. These characteristics make the hydrochars suitable for energy recovery as fuel. Moreover, the concentration of nutrients in hydrochars and the solid texture similar to peat make them a valid substitute in growing media, prospecting agricultural uses as soil ameliorant. Numerous germination tests on cress seeds were carried out demonstrating the feasibility of the hydrochar for agricultural purposes. Lastly, the higher surface area and the properties similar to activated carbon suggest the use of hydrochar as adsorbent for contaminants. In addition, process water was characterized in terms of pH, electrical conductivity, and concentration of nutrients and toxic organic compounds such as HMF, furfural and phenolic compounds. Biological treatments, like anaerobic digestion, were suggested to handle this by-product. In this context, Biochemical Methane Potential (BMP) tests were applied to give very promising results. Many of the results obtained have been presented to numerous international conferences and they will be published soon in international journals.

Characterization of fine and ultrafine particles in different exposure scenarios

Gabriele Marcias



The research is focused on Characterization of fine and ultrafine particles in occupational and environmental settings such as a steelmaking foundry, military airport, urban and industrial areas. Furthermore, the research aims to investigate potential early biological effects due to exposure to fine / ultrafine particles or others environmental pollutions. The title of his thesis is: *Characterization of fine and ultrafine particles in occupational and environmental settings*.

During the research activity Gabriele collaborated with several universities including the King Abdullah University of Science and Technology (KAUST).

The research is carried out through a multimetric and multidimensional approach. In particular, airborne particles were investigated using an electric low-pressure impactor (ELPI+™), a Philips Aerasense Nanotracer or DISCmini and traditional sampling equipment. The ELPI+™ is connected to a vacuum pump with a flow rate of 0.6 m³/h and a pressure of 40 mbar measured at the final stage of the impactor. This instrument, through the dimensional selection of airborne particulates, detects in real time the particle diameter (sizes between 6 nm and 10 μm), the concentration and, based on the data collected, provides an estimate of the concentration in surface area / mass / volume of sampled particulates. Furthermore, personal collection of particulate matter was done using portable particle counter, which allows the real time measurement of particles number concentration and the lung-deposited surface area concentration. The research was also directed to the chemical and morphological characterization of the airborne particulate to determination of metallic elements in the collected particles.

These analyzes were conducted through inductively coupled plasma mass spectrometry transmission and scanning electron microscopy, the latter together with energy dispersive X-Ray spectroscopy based spatially resolved compositional mapping.

Marcias G., *et al.*, Occupational Exposure to Fine Particles and Ultrafine Particles in a Steelmaking Foundry, *Metals* 9(2): 163 (2019)

Conversion of plant wastes into products of cosmeceutical and nutraceutical interest

Matteo Perra



Matteo graduated in 2018 in Pharmacy at the University of Cagliari, with an experimental thesis in Pharmaceutical Technology entitled “Needle-free cutaneous administration of diclofenac nanosuspension”. In 2019 he joined the XXXIV Cycle of PhD program in Earth and Environmental Sciences and Technologies at the University of Cagliari with a scholarship funded by PON, under the supervision of Professor Gianluigi Bacchetta. His PhD project is an interdisciplinary study involving two departments DiSVA and DICAAR of the University of Cagliari. The project is focused on the conversion of agro-industrial wastes into valuable products, in particular the extraction of valuable bioactive compounds from these by-products, to obtain nutraceutical and cosmeceutical products, and the conversion of the obtained exhausted biomasses into amendments. The idea is to create an eco-sustainable supply chain for obtaining plant raw materials and /or biotechnological products.

Starting from September 2019 and January 2020, the PhD student spent four months at the University of Granada (Spain) to enrich his knowledge on both the most effective and eco-friendly methodologies for the extraction of phytochemicals from agri-food residues and their characterization.

As reported above, the PhD-PON project is focused on the valorization of agri-food wastes into valuable products through economical and environmentally compatible strategies. In particular, the PhD student focused into the conversion of grape pomaces, a by-product obtained during the vinification process. In literature is widely reported the beneficial properties of grapes and grape by-products, due to their

high content in bioactive molecules, such as polyphenols, with antioxidant and anti-inflammatory properties.

The extractions of these bioactives were performed by maceration, using eco- and bio-compatible solvents, and the main components of the extracts were identified and quantified. Then the extracts were incorporated into phospholipid vesicles to obtain nutraceutical and cosmeceutical products. The main physico-chemical (size, zeta, entrapment efficiency) and technological properties were evaluated, as also their biocompatibility and protective effect against oxidative stress induced by using hydrogen peroxide using an *in vitro* cell model. Overall results suggested that grape pomaces extract loaded phospholipid vesicles are biocompatible and can protect the skin against oxidative stress.

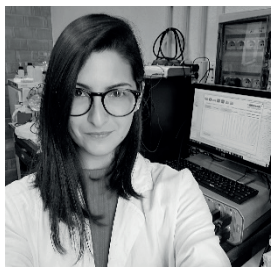
According to the circular economy principles, the exhausted pomaces, obtained after the extraction process, and grape stalks are currently being used as substrate to obtain compost. Various parameters, such as temperature, volatile solids, total solids, pH and conductivity, are periodically monitored.

In the end, germination tests will be performed at the Botanical Gardens of Cagliari (Hortus Botanicus Karalitanus), to evaluate if the obtained compost can be used as agricultural amendment.

The expected results could mark an important step towards the acquisition of eco-sustainable techniques for the adequate exploitation of agri-food by-products which from waste become valuable substrates from which it is possible to obtain products of high commercial interest such as health, biotechnological, agronomic and energy products.

Bioremediation of multi-contaminated groundwater using advanced systems

Giulia Puggioni



Giulia Puggioni took her MSc degree in Environmental and Land Engineering at the University of Cagliari in 2018. She has always been interested in research, especially in the water sector, and started to work on advanced wastewater treatment systems during her master thesis entitled “Application of bioelectrochemical technologies for the nitrogen recovery from wastewater with high ammonium content”. With the beginning of her Ph.D. in Earth and Environmental Sciences and Technologies, she continued her studies on this new technology, focusing on groundwater treatment. Since the first year of her Ph.D., she has made experiences abroad, at the Laboratory of Chemical and Environmental Engineering (LEQUiA) of the University of Girona (Spain), with which she has continued the collaboration throughout her Ph.D. thanks to the signing of an agreement for the joint supervision of the thesis.

Her research project, entitled *Bioremediation of multi-contaminated groundwater using bioelectrochemical systems*, focused on the application of bioelectrochemical systems mainly for the removal of nitrate from saline groundwater. All over the world, groundwater represents one of the main sources of drinking water supply and agricultural irrigation. However, in both developed and underdeveloped countries, this crucial water resource is threatened by multiple polluting sources, both natural and anthropogenic, which limit its possible exploitation for human consumption. One of the most widespread pollutants is nitrate, which can accumulate in groundwater mainly due to agricultural-related activities such as the spread of inorganic fertilizers and animal manure on crops. Besides nitrates, high groundwater salinity is a matter of concern since it limits its possible use for irrigation. Convention-

al technologies for groundwater treatment such as reverse osmosis, ion exchange, and electrodialysis are mainly based on separation, or they require external chemical addition to catalyze the process. Moreover, these strategies are characterized by high costs for energy and chemicals consumptions, as well as by the production of wastes that are difficult to be disposed of. Bio-electrochemical systems (BESs) proved to be a promising low-cost, sustainable, and efficient alternative for nitrate and salinity removal from groundwater. In BES, the electrochemical redox processes are enhanced by electro-active bacteria, which can use a solid electrode as electron donor or acceptor. Within this framework, a novel 3-compartment bio-electrochemical cell configuration was designed and tested in order to verify the possible application for the on-site treatment of saline groundwater contaminated by nitrates. The study is based on a real case of groundwater contamination in the municipality of Arborea (Sardinia, Italy). Here, an extended area has been designated as Nitrate Vulnerable Zone (NVZ), since nitrate concentration in groundwater exceeds the threshold limit of $50 \text{ mg NO}_3^- \text{ L}^{-1}$ which has been set by European ("Nitrate Directive" 91/676/EEC; "Groundwater Directive" 2006/118/EC) and Italian (D.Lgs 152/2006, part III, Ann. 7A-I) regulations. In addition to nitrogen pollution, such groundwater is also affected by high conductivity, which is partly related to agricultural activities. The 3-compartment cell was operated in both potentiostatic and galvanostatic mode, and different operating parameters were applied: process performances were compared in terms of, among the others, nitrate and salinity removal efficiencies and rates, and specific power consumption. WHO and European threshold limits for drinking water were considered as target values for the cell effluent. An extensive set of information was gathered, and results will be useful for the development of novel BES configurations and operating strategies for the efficient and cost-effective on-site remediation of high salinity, nitrate contaminated groundwater.

Study of mineralurgical processes for the treatment of mining waste

Giulio Sogos



Giulio was born in Cagliari on 24 June 1989. He is graduated with honours in Land and Environmental Engineering at the University of Cagliari. After graduation, he worked for six months as executor of laboratory tests for the recovery of mining residues. Since October 2018 he started a PhD in “Earth and Environmental Science and Technologies” at the Department of Civil, Environmental Engineering and Architecture (DICAAR).

The title of the thesis is: *“Study of Mineralurgical Processes for the Treatment of Mining Waste”*.

The research work is focused on the application of the flotation method as a reclamation technique for mining waste, which includes waste rock, tailings, and slugs. Tailings disposal constitutes one of the issues with the greatest environmental impact. Environmental pollution from mining activities includes the generation of acid mine drainage (AMD) with consequent damage to the water quality and ecosystem, air pollution, dam collapses and sinkholes. The aim of the work is twofold: on the one hand to declassify tailings into non-polluting materials, reducing the concentration of heavy metals in compliance with the legal limits of the Italian Legislative Decree no.152/2006, so that the waste can be used for other purpose and, on the other hand, to obtain a metal marketable concentrate that allows to repaying reprocessing costs. The choice to apply a remediation process through flotation is part of the research activity of DICAAR at the University of Cagliari, which aims to evaluate flotation as a remediation technique for mining waste with low lead and zinc contents.

A representative sample was obtained from the Montevecchio Levante (SW Sardinia, Italy) tailings dam, in which analysis had shown

high concentration of Zn, Pb, Cu, Cd, As, and Sb. According to the results of qualitative XRD analysis, sphalerite was the main valuable mineral. After an extensive review of the scientific literature, in order to design a possible plant flowsheet, laboratory tests were carried out to determine the optimal process parameters. The effect of particle size, the effect of type and dosage reagents and the effect of desliming were studied. In addition, the effects of the number of cleaner and scavenger steps, required to achieve both the remediation and economic goals, were assessed.

The study involved more than 150 flotation tests and the reconstruction of about 25 plant flowsheets. The concentrations of heavy metals were measured by ICP-OES, and the effects of the parameters studied were assessed, based on both the metal contents of the output products and the values of the contaminant removal efficiency.

Soil remediation methods, based on physical and physico-chemical separation processes, can also be applied for the remediation of marine sediments. During the last year of the PhD programme, the research focused on the remediation of the Zn and Hg polluted marine sediments, obtained from the industrial harbour in Portovesme (SW Sardinia).

Manca P.P., *et al.*, The flotation of sphalerite mine tailings as a remediation method, *Minerals Engineering* 165: 106862 (2021)



PhD programme in History, Cultural Heritage and International Studies

Coordinator: Cecilia Tasca

Vice-coordinators: Mariangela Rapetti, Christian Rossi

The international PhD in History, Cultural Heritage and International Studies of the University of Cagliari, in agreement with the Federal University of Goiás (Brasil), aims to train highly qualified scholars within the studies of History, considered in its multiple facets and meant as a process of knowledge of the past which provides useful insights into the current world, into the spatial and territorial conditions and the dynamics regulating its social functioning also from an international perspective. In the framework of its primary interests and educational process, the PhD combines history *sensu lato* and considered in its widely acknowledged time periods (ancient, medieval, modern, etc.) and cultural heritage in its broader sense (archaeological, artistic, cinematic, musical), with a focus on Sardinian history and 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 multidisciplinary and comparative approach. Teaching is thus structured in several educational stages offering a basic research methodol-

ogy in humanities, with a focus on the historical and historiographical approach, through a synchronic perspective which enables to observe the events in the context which has actually produced them and where they have occurred, and a diachronic perspective which favours the connections between different eras and geo-cultural areas, also from an interdisciplinary perspective.

The educational path represents an opportunity for growth and maturation within an inspiring academic environment which provides the PhD candidates with a valuable wealth of knowledge and skills regarding the management and promotion of historical and cultural heritage, financial resources in the field of research and European and extra European planning, development of European and extra European projects, mainly focused on the field of Cultural heritage, History and International relations, management of cultural-historical heritage, communication and scientific dissemination.

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

Cinema and Video Games: Rethinking Film Education

Massimo Atzori



I was born in Oristano in 1979. After my Degree in Foreign Languages and Literatures at the University of Cagliari, I started to work as a cultural operator at Centro Servizi Culturali U.N.L.A. in Oristano, focusing my attention especially on cinema related activities. In 2015, I became tutor of Cinema, TV and New Media course at the University of Cagliari, Faculty of Humanities; I worked as such till 2019. Since

May 2020, I have been an expert of cinema at the University of Cagliari.

In September 2018, I started my experience as a Ph.D student with a research project on the relation between cinema and video games from an educational perspective; I made this choice because some years earlier film education had been introduced at school in Italy at last, therefore I was interested in finding new ways to teach cinema to young students, the so called digital natives as defined by Marc Prensky. Through a theoretical speculation on the old medium and the new one as two of the most important audiovisual media, I have tried to investigate the educational potential of this connection.

During the first year, I started a bibliographical research in order to discover the state of the art of the relation between cinema and video games and define the boundaries of my project. After collecting a good number of sources, I decided to focus on machinima as a point of media convergence with educational potential to explore and nurture. During the second year, spent as a Visiting Researcher at a leading university such as Brunel University London/ Games Design division in Uxbridge (UK), I had the opportunity to study the broad field of games from a multidisciplinary perspective; thanks to some interesting discoveries, I started to develop my film education hypothesis based on

machinima and then write my thesis whose title is *Cinema e videogiochi. Convergenze mediali e metodologie didattiche innovative per la film education del futuro*.

Machinima is probably the most interesting case of media convergence between cinema and video games; this term comes from the merger of two words, machine and cinema (or animation) and means “animated filmmaking within a real-time virtual 3D environment” (Marino, 2004: 1). This hybrid medium rose during the 90’s, mainly related to the first person shooter genre, as a way to appropriate video games technology by hardcore gamers, then it became widespread among the wider game community. In the essay “Everything I Need to Know about Filmmaking I Learned from Playing Video Games: The Educational Promise of Machinima” (2011) by Matthew Payne, it is possible to find the foundations of a new way to conceive film education through machinima; it can be included in the innovative theoretical framework of game-based learning and fit the recent framework for film education released by British Film Institute in 2015, which highlights creativity as one of the three main interrelated dimensions of film education since the digital revolution and the shift of spectators from viewers to makers.

“For a total regeneration of the island”: Il *Partito sardo d'azione* and its political and organizational recovery (1943-1969)

Stella Barbarossa



The research project intends to enrich the knowledge of the political, social, and economic events within the *Partito sardo d'azione* (Psd'az), a political force with a strong autonomist vocation, which in the first few years of the immediate post-war period disputed the leadership in the island territory with the *Democrazia cristiana*, in the first twenty years of autonomist government of Sardinia (1949-69).

The reconstruction of a documentary corpus of the Psd'az will be fundamental to outline and pre-define both the role played by the party in the first regional governments in the management of autonomy, and the planning of the interventions approved by the Giunta and the Sardinian Regional Council for the super-landfill of the problems that made Sardinia not only geographically and economically isolated but backward. The study will continue with the analysis of the Sardinian parable during the Fifties and Sixties, which will see an electoral recovery of the Psd'az and the start of the center-left season. Important and decisive years also because they mark the debate and the subsequent launch of the Renaissance plan in Sardinia, which on the one hand will be a harbinger of radical economic and social transformations capable of transporting the island into modernity, on the other it will have serious repercussions on the plan politics, which will culminate in the end of the Sardinian center-left government experience and in the crisis of autonomy.

The documentary heritage of the *Partito sardo d'azione* is currently preserved at the headquarters of the Sardinia Foundation, and has been declared of historical interest by the Sardinian Archival Superin-

tendency on 2 February 2009. These are mainly the documents and correspondence of the main institutional bodies central and peripheral of the party, as well as a rich documentation that testifies the relationships with the other island political formations, national and inter-national. The fund also presents the administrative documentation relating to the membership and the publication activity of the weekly magazine "*Il Solco*", the party's press agency.

My research project aims to analytically study the reconstruction and evolution of the Sardinian Action Party from 1943 to 1969 thanks to the use of these recent and unpublished documentary sources and has the intention of enriching the knowledge of political events, social and economic internal to the Party which, in the very first years of the immediate post-war period, fought for leadership in the island territory with the Christian Democrats, in the first twenty years of autonomous government of Sardinia (1949-69). Up to now, the work has consisted in the creation of three guides to the sources, relating to the funds examined: Sardinian Action Party, Giovanni Battista Melis and Pietro Melis for a filing of 975, 137 and 6,804 files respectively. Inside the guides there is material referable to the chronological period from 1943 to 1969, collected through the examination of numerous types of printed and manuscript sources.

Sacred Harp: the many dimensions of a glocal singing community

Delia Dattilo



I am a PhD candidate in Ethnomusicology at the University of Cagliari (PhD course: History, Cultural Heritage and International Studies). I held a Master in Musicology at the University of Palermo and a Post-MA certificate in Analysis and Theory of Music at the University of Calabria. I am currently founder and director of the book series “Geologie Umane” (Ferrari Editore), through which I’ve edited three collec-

tive volumes, with the grant of the Italian Ministry of Cultural Heritage and Activities, Mibac. Before the PhD, I have been very much interested in soundscape, and rave culture. My first contribution on the latter topic was published in *Studi e Ricerche* (vol. IX, 2016, University of Cagliari) and, lately, in the proceedings of the 11th Conference of Interdisciplinary Studies, *Crisi e Trasformazioni* (2020, University of Rome “Tor Vergata”). I am also interested in Anglo-American traditional music, both secular and sacred, the second being the subject of my PhD dissertation on sacred harp singing and its revival in some European local communities. Many traditional tunes of secular and sacred origin persist in the “dispersed harmony” of Southern Americans’ “singing families”, and, because of a renewal of the Sacred Harp in the 2000s Europe, new singing communities are experiencing a deep understanding of this music path, combining diverse spiritual dimensions in which each one, supporting his/her local group, gathers also with the other ones, and builds his/her own imaginary, participating, practicing and learning how to perform these old sacred songs, in a very close way (it’s participatory, and not presentational music in a strict sense). Thus, my research is based on the analysis of the musical competence, performance, and strategies of transmission, but also

on many aspects related to the Sacred Harp traditional repertoire and its multipart written profile, which I've research and studied through dozens of American 19th century songbooks. I had the opportunity to do fieldwork and field-recording between the second half of 2019 and the beginning of 2020, joining regular singing held in Dublin and two big singing (the Double "All-Day" in London, UK, and the 10th Ireland Sacred Harp Convention, in Cork, Ireland). After participating in the call for paper of the Kommission für Volksdichtung (University of Aberdeen, Scotland, UK), for the 50th International Conference on Ballad Studies (May 2020, University of Tirana), I have been invited to speak about these experiences with a paper titled *This new "singing families". Reasons and expectations around an intimate multipart singing*, which would be presented in 2022. Due to the spread of Covid-19 these singing had been suspended and some of them have moved online. Being fundamental for the analysis, I replaced the absence of the "live" fieldwork with the "online" participation at virtual events, combining ethnographic methodologies to approach many unpredicted situations (online singing and interview, contributions at collective recording and music writing). Although many elements and peculiarities of a singing convention's soundscape have been radically changed, the expectations of many singers went towards the representation of these "lost" environments, by using all the possible virtual strategies to reproduce a sacred harp singing gathering. I've discussed some of these aspects at the virtual conference "Sounds of the Pandemic" (Dec 2020, University of Florence).

Implications of Brexit in the international economic context

Piotr Dariusz Grabara



Piotr Grabara is a third year PhD student in History, Cultural Heritage and International Studies at the University of Cagliari. He has an economic background with a Master's degree in International Relations from the Wrocław University of Economics (Poland), with specialization in Foreign Trade. He is dedicating his research to the issue of Brexit, by comparing the

reasons that have pushed the United Kingdom to join the European Union in the past and the reasons that are causing the current separation from the EU. The analysis of the ongoing Brexit process is therefore the main theme of his doctoral thesis entitled: *"Geopolitical and socio-cultural implications of Brexit in the international economic panorama"*.

During his PhD he made several trips to the United Kingdom to participate in conferences dedicated to Brexit issues and visited Queen's University in Belfast in the Northern Ireland and the Irish border, learning about the different issues in that area, that were crucial to the Brexit negotiating difficulties. He presented the first analysis of his research at the XI Interdisciplinary Conference of PhD students and PhDs on theme "Crisis and transformations" at the University of Rome Tor Vergata and more recently at the EDUC online scientific seminar of European Union Studies. He has also concluded the digital Erasmus Placedoc+ traineeship at the Jan Długosz University in Czeszochowa (Poland), where he jointed collaboration with the co-author of a book regarding the security and safety in Europe.

In his research, he analyzes the geopolitical and economic changes between the United Kingdom and the European Union after the historic referendum from 2016, using his unique interdisciplinary approach of confronting relevant historical events, with mainstream political

agenda, economic consequences of the decisions and socio-cultural impact of the changes on the local communities.

He concentrates his analysis of the situation post Brexit in the most conflicted areas such as the fisheries, the level playing fields, and the border between the Republic of Ireland (EU) and Northern Ireland (UK) that were holding back the Brexit negotiations, with a risk of not achieving the treaty before the deadline. He examines the fulfilment of the Britain's final trade agreement with the EU, that was achieved only one week before the end of Brexit transition period. This very short notice results in the emerging of many critical issues on how to actually implement the agreement. In his work he analyzes the official government documents, as well as articles from different journals, documentaries, and reports in the news and the social media, regarding the practical problems risen from the new status quo. He compares the final Treaty to the previous proposals made by former Prime Minister, but rejected by the Parliament, to the alternative no deal solution, that some Brexit enthusiasts would prefer.

As a result of his study, he provides the quantitative consequences of the political agreement, by comparing it to its impact on the general British economy and on some specific groups of stakeholders. Both sides of the Brexit vote spectrum have been analyzed to provide the most possible objectivity, through the support of the economic results and the changes of the currency value in correlation to the political choices. He evaluates possible legal implications set by the Treaty to guarantee its effectiveness. In conclusion, he puts the final Brexit Free Trade Agreement to a test, against the supposed benefits according to the political promises, and the real impact of the decisions measured by objective economic data and legal framework.

The narration of the *Risorgimento* in the regional newspapers: a digital public history project

Erica Luciano



Erica Luciano (Cagliari, 1990), contemporary historian. Degree in Modern Letters at the University of Cagliari; Master's Degree in History and Society at the University of Cagliari; Professional Master's Programme in 20th-century History at the University of Roma – Tor Vergata.

Since 2018, PhD candidate at the University of Cagliari with a research project - winner of a PON RI 2014-2020 scholarship for industrial doctorates - on the *Risorgimento* period, under the supervision of tutors prof. Luca Lecis and prof. Cecilia Tasca.

Specifically, the candidate aims to analyze the narrative of the *Risorgimento* that was given by the two main regional newspapers, *L'Unione Sarda* and *La Nuova Sardegna*.

After the first phase of bibliographic research on the subject and on the period in question, the candidate carried out dense research work at the Municipal Historical Archives of Cagliari and the University Library of Cagliari, which preserve the archives - almost totally digitized - of the two newspapers.

The research objectives were to identify and acquire any article - from the birth of the two newspapers to today - that dealt with any aspect of the *Risorgimento*.

Subsequently, the candidate - using the open-source content manager Omeka - developed two collections for both the newspaper and a form template to file all articles with suitable metadata.

In a second phase, these articles will be made available through the portal of the Interdepartmental Center for Digital Humanities of the University of Cagliari.

Due to its objective and the tools used, the research project is placed between public history and digital history, explored by the candidate thanks to different training experiences.

Among these, attendance at the LUDi.Ca University of Cagliari Digital Humanities laboratory, participation in the summer school “Media and history” organized by the Italian-Germanic Historical Institute of Trento and a traineeship at the Department of Digital Humanities of King’s College of London. Furthermore, during the British experience, the candidate was able to actively participate in the construction of topics and digital collections within the international project Archives Portal Europe, a web service capable of making access to the documentation of European archives as accessible as possible.

Women's memories of Oudlājān: From a communitarian neighbourhood to a placeless city

Monica Mereu



Monica Mereu is a Ph.D. candidate undertaking a doctoral program with a focus on Persian Studies. She holds a bachelor's degree in Humanities at the University of Cagliari. In 2018, after several international university experiences, she received her master's degree in History and Society magna cum laude. During this time, she studied Persian Language at University of Cagliari. For a semester she studied history and

Persian language at the University of Tehran.

The project aspires to investigate one fascinating and at the same time complex aspect of the Iranian society, focussing on the reconstruction of the history of the female component of the Jewish community of Tehran that used to live in Oudlājān (the Jewish quarter of the Iranian capital) and then moved out during the 1950s. The project is developed according to an interval of time that follows the chronological succession of the historical path of Oudlājān, from the last decades of Reza Shah (1925-1941). The project is built on three topics, which correspond to the progression of the events of the above-described period and, consequently, on the three chapters of which this project is composed: Oudlājān during Pahlavi; the transformation of Oudlājān and the abandonment of the quarter; Oudlājān today. The aim of the project was to give voice to the Jewish women of Oudlājān and recall the story of contemporary Tehran from their perspective, while focusing on cultural aspects and daily life memories.

This specific approach to the research that involves the recourse to memory has been possible through a series of different fieldwork research studies that the Ph.D. candidate conducted in Tehran during the first years of her research (July-September 2019 and November 2019).

The first sources of the research were autobiographical interviews, which were conducted mainly in Persian. All the research was, indeed, based on a collection of stories and memories composed through different interviews with women who lived in the Oudlājān neighbourhood or have memories of their families living there. The goal was to give voice to these Jews who still retain a genuine and truthful memory of the neighbourhood and are able to represent it with great dignity and value. During the Covid19 pandemic, the interviews were conducted remotely. For this reason, the research mainly engaged in semi-structured interviews.

During the PhD research the candidate has been Visiting Research Scholar at the University of Tehran and then at the Institute of Iranian Studies at the Austrian Academy of Sciences. In collaboration with the University of Pennsylvania, the candidate is carrying out a project entitled "Jews in the City: Urbanity, Jewish Quarters, and Modernity". Her contribution for the project is entitled "Stories from Oudlājān: The Revaluation of the Neighborhood Through Memories".

She has been speaker at several seminars and conferences on different disciplines, reflecting the highly multidisciplinary character of her research project. She has published different academic articles, including: Mereu M., Oudlājān Memories. The Iranian Jewish Community of Tehran from a Female Perspective, in *The Jewish Diaspora after 1945: A Study of Jewish Communities in the Middle East and North Africa*, ed. S. Behnaz Hosseini (Newcastle upon Tyne: Cambridge Scholars Publishing, 2020), 2-26.

Hospitality: a central concept for a paradigm of 'mobilities'

Gaspare Messina



Gaspare Messina's educational pathway has focused on migration in Sardinia since his research thesis in Ethnology at the University of Cagliari in 2013. He has continued his studies with a master's degree at the University of Milano-Bicocca, where he had perfect techniques and models of the Anthropology of Migration. He spent one year engaged in National Civil Service activities involved in the reception of asylum seeker migrants. In 2018 he started his PhD path, benefit from a scholarship funded by the "Istituto Superiore Regionale Etnografico" of Sardinia, working on the theme of "Ethno-anthropological methodologies and cultural change in Sardinia".

Specifically, his research entitled *"The welcoming of migrants and tourists like a mirror of Sardinian hospitality. Spontaneous solidarity, tourist reception and migratory flows' management"* is aimed to investigate whether, after 2014, relations between 'autochthonous and 'foreign' populations are still marked by those practices that, in 'native' and non-native narratives and representations, have contributed over the last centuries to the production of a positive account of the island and its inhabitants' hospitality. 2014 is not an arbitrary date but constitutes a watershed in the Sardinian's reception of migrants because of having become an institutionalised practice and no longer spontaneously organised by individual subjects or Third Sector associations. The Reception System managed by the Interior Ministry has indeed recommended and/or imposed, even in the small inland centres, the activation of organisations that would take charge of the management of asylum seekers. The desire to address this issue from a multidisciplinary and anthropological perspective has led to an analytical effort to investigate

the identity-building practices implemented by the 'natives'. From a diachronic perspective, he has resort to the tools of cultural studies, historical and historiographic analysis, social geography, comparative analysis, and, of course, ethnography.

Before the Covid-19 pandemic prevented the in-person academic activities, he benefited from the indispensable experience of participating in national and international conferences, lectures, seminars, and workshops. Among these, the most relevant were: the participation at the "6ème Séminaire Annuel du Réseau Migrations" organised by the École des Hautes Études en Sciences Sociales (EHESS) in Paris about Migrations et espaces publics: discours, pratiques et postures in June 2019; the participation in the 1st edition of the international summer school "MeditHerity - Mobility and Heritage in the Mediterranean: tourists and Migrants (un)expected encounters in the Mediterranean" held in Malta in September 2019; the participation in the project "Cosmomed – Tracce di cosmopolitismo: migrazioni, memorie e attualità fra Mediterraneo ed Europa" organised by the University of Cagliari; the presentation of a contribution at the workshop entitled "Anthropology of Islands. Reflecting islandness from a historical and cultural studies perspective" organised by Institute of European Ethnology of the University of Wien in November 2019.

From December 2020 to May 2021, he did a distance learning traineeship at the Islands & Small State Territories Institute of the University of Malta. On that occasion, he has had the opportunity to broaden his gaze comparing the Maltese and Sardinian approaches to the phenomenon of international mobility both in the field of international migrations and mass tourism.

The Jewish community of Istanbul suspended between Erdoğan and Aliyah

Alessandro Porrà



I graduated in Political Science at the University of Cagliari and I am currently a PhD student in History, Cultural Heritage and International Studies with a doctoral research that focuses on the Jewish community of Istanbul and that includes minority studies, nostalgia studies, memory studies, Jewish studies and oral history.

During my research path I have explored Istanbul Jewish community over the last two decades through memory, archival research and artistic-cultural heritage as revealed in the narratives and visual sources of the interviewees.

The main object of my PhD project is to evaluate the relationship between the Turkish Jewish community and the phenomenon of Nostalgia for Ottoman “cosmopolitanism”, a topic that since the 1980s has become central to Turkish political and cultural debate; at the same time the research aims to understand whether the Jewish community in Turkey shares the political project of “neo-Ottomanism” and its declination in terms of popular culture known as “Ottomania”, or, quite the opposite, the community tends to feel more connected to the Kemalist past and to what has been defined as “Kemalist nostalgia”, a feeling also widely present in contemporary Turkish society and politics.

First of all, the intent of the research is to understand how the effects of historical events, both past and present, affect the Turkish Jewish community today and the choice made by those who feel primarily Turkish citizen to do not make “*Aliyah*” towards Israel despite either the Zionist ideology or the socio-political situation of Turkey would push them to do so, and, in the second place, the research want to de-

fine the relationship between the Turkish Jewish community its places of memory, and the present.

The research methodology is part of a definitely multidisciplinary discourse that embraces historical, sociological, and anthropological studies and part of that "Area studies", where direct knowledge is an essential and indispensable element and where the internal point of view of the subject examined in the research is as fundamental as, if not even more, than the external one.

Therefore, due to the objectives of the research, *qualitative research*, in its form of "oral history", conducted through semi-structured and auto biographical interviews, proved to be as the most appropriate methodology to be used in this study project as the interview primary purpose is to access the perspective of the subjects, grasping their conceptual categories, their interpretations of reality and the reasons for their actions. This methodological process allows us to understand how the interviewees handle and judge the historical events examined, what direct experience they had of them, what their reflections were then and now, and how the set of these experiences constitutes the social fabric of the object of the study.

Therefore, I believe that this epistemological system is the most functional to express, with great accuracy, the representation of the point of view of the actors involved who represent the focus of research itself, and that this analysis from the inside allows us to build the structure of the narrative account of causal processes hidden behind the historical facts.



PhD programme in Civil Engineering and Architecture

Coordinator: Ivan Blečić

Vice-coordinator: Roberto Deidda

The PhD in Civil Engineering and Architecture places the territory and the built environment at the centre of scientific interest, understood as a complex research field including the historical and contemporary built systems, road and hydraulic infrastructural works, the environment and the natural and man-made landscape, with particular attention to the interconnections between environment, economy and society. The vast field of investigation stimulates an interdisciplinary vision of the topics addressed and favours the integration between basic and applied research. The cultural and scientific heritage of the Doctorate is manifested in the scientific production concerning, among others, the recovery and enhancement of historical and contemporary building fabrics, the conservation and protection of the architectural and landscape heritage, architectural composition, urban and territorial planning, urban studies, management of water resources and transport, the protection and safety of territories from adverse weather events, static and dynamic safety, with significant repercussions not only on the academic level, but also on the institutional and social level.

Within this context, the primary objective of the Doctorate is research training and the acquisition of methods and tools for conducting research projects, together with highly qualified teaching skills. Particular attention is paid to the consolidation of the autonomous ca-

pability to conduct original research programs on the topics covered by the Doctorate. The doctoral researches by PhD students are conducted in collaboration with the international scientific community, and are aimed at providing specialised contributions to the advancement of the scientific research, but also at providing concrete answers to technical and operational problems in relation to sustainable development and territorial governance.

In this sense, the Doctorate also pursues technical-operational objectives, coherently with the professional connotation and service to the territory of the disciplines of civil engineering and architecture, in which basic research is combined with applied research, with significant social repercussions. These objectives aim to strengthen the abilities of PhD students to identify the existing relationships and interconnections between engineering, architectural, technological, environmental, economic and social aspects.

The advanced training acquired during the doctoral course and the constant stimulus deriving from the interdisciplinary context that characterizes the Academic Board, contribute to the formation of researchers able to address complex problems concerning the management of the territory and its transformations in its broadest sense and compatible with sustainable development.

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

<https://dottorati.unica.it/dotticar/>

Digital games and interactive storytelling for cultural heritage

Sara Cuccu



Architect and PhD candidate in Civil Engineering and Architecture at the University of Cagliari. After her graduation in Architecture in 2018, she starts a brief collaboration with the Onlus IIC (Istituto Italiano dei Castelli), works in an architecture firm and won a PhD scholarship. The doctoral research project, with the original title *Gamification, Geotelling and Interactive Storytelling for Cultural Heritage*, is supervised by the professors Ivan Blečić and Maurizio Memoli, and is funded under the National Operational Programme on Research and Innovation (PON-RI) 2014-2020, issued by the Italian Ministry of University and Research and co-funded by the European Social Fund (ESF).

The theme of the research project is the promotion and valorisation of cultural and environmental heritage, both tangible and intangible, through digital games and interactive storytelling. The main objective is to experiment alternative models of heritage promotion and valorisation for cultural-touristic purposes. In fact, it proposes a particular kind of digital games: first-person cinematographic video games. This kind of video game are a hybrid of cinematographic language and the interactivity typical of gaming, where digital environments are not 3D reconstructions, but the resulting composition of videos and/or pictures of real places. The idea was developed in the top-down cluster project PAC-PAC, promoted by the DICAAR (Department of Civil, Environmental Engineering and Architecture), under the scientific coordination of prof. Blečić. To understand and master PAC-PAC's methodologies and techniques, she collaborated in the production of a video game set in the Mine-Geopark of Sulcis-Iglesiente (Sardinia). These methodologies and techniques were tested in a different context with

the project's company partner, Space S.p.A, which work is focused on ICT for cultural heritage.

The research project was conceived for enhancing awareness for cultural heritage, using real locations as game worlds, following the idea that real places in digital games can produce a more profound connection with the players. This assumption is the ground for the theoretical investigation of the thesis, explored deeper in the research period abroad at the Institute of Digital Games in Malta.

Video games are a worldwide diffused medium, with a great impact on pop culture and effects on the way we think, act, and learn. They have the peculiar capacity to foster immersion, agency, and transformation, and are therefore able to give virtual worlds a symbolic and cultural meaning, like real places. Hence, these virtual places can be experienced as real places, where we can observe unusual spatial practices, sometimes even subversive. Spatial uses, and the space issues more in general, are the key link between video games and architecture.

The spatial engagement is the distinguishing trait of the medium, and the connection with space can create an affective relation with represented places. The representation of reality and physical places in game worlds is a relevant topic, and is gaining attention not only from game designers, but also architects and urbanists. In fact, an accurate representation is not just an extra value, particularly important when it involves cultural heritage, but can make the difference in the choice of a game. Video games also proved their potential in communicating the values of cultural heritage and increasing the interest in places, attracting visitors, and even inducing tourism. This explains the use of digital games in the communication and promotion of heritage, a practice well-known that involves companies, museums, and institutions.

Blečić I., *et al.*, First-person Cinematographic Videogames: Game Model, Authoring Environment, and Potential for Creating Affection for Places, *JOCCH* 14(2): 1-29 (2021)

Hydrogeological risk reduction measures in response to climate change

Stefano Farris



My name is Stefano Farris, and I am currently enrolled in the third year of the PhD course in Civil Engineering and Architecture. I graduated from the University of Cagliari in Civil Hydraulic Engineering in February 2018 and, after a short research experience of a few months at the same University, I started my PhD. My research is mainly focus on the statistical analysis of extreme precipitations, on the study of the potential impacts on environment and on the feasible measures to mitigate such effects.

During my PhD I studied how the frequencies of extreme precipitation events are changing on time at global scale, since potentially increases driven by global warming are expected. In light of this, I investigated whether the presence of such foreseen trends is actually detectable on real observed precipitation data. In order to do this, I carried out several analyzes involving the application of statistical trend tests and different procedures aimed at reducing biases that can potentially affect the trend analyzes and lead to misinterpretation of the corresponding results. These studies revealed many significant and mostly increasing trends around the world, suggesting clear evidence of a real increase in extreme precipitation events.

Potential critical impacts can be produced by extreme precipitations in urban areas. Forecast systems represent one of the most effective non-structural mitigation measures. During my PhD I also focus on nowcasting models, which concern various procedures aimed to produce short-term forecasts. Specifically, I applied several nowcasting models to high-resolution radar data retrieved by an X-band radar monitoring the metropolitan area of Cagliari. The results showed good

forecast performances and a real effectiveness of these procedure in the considered case study. Higher performances have been achieved by combining the aforementioned radar data with the low-resolution data measured by the national radar network and defined for the whole Italian area. For this purpose, a specific procedure has been developed by merging the spectral information of the two data while preserving the higher spatial resolution and combining large-scale advection with the statistical properties of smaller scales.

Similarly, the mitigation of the rainfall-related impacts can be ensured through structural measures aimed mainly at reducing runoff. In light of this, part of my research focused on the analysis of some sustainable systems, such as green roofs and rainwater harvesting systems, and on the estimation of the corresponding potential performance that can be guaranteed at urban scale. The results suggest that these systems can be highly effectiveness and that their proper combination can be produce significant reductions of the urban runoffs.

Planning the regeneration of disposed public real estate

Alessio Floris



Architect. Graduated with honours in 2015 in Architecture at the Faculty of Engineering and Architecture of the University of Cagliari, with a thesis focused on the containment of urbanisation phenomenon. After gaining experience in a few architectural firms, he continues his professional and research path by contributing to the organisation and development of a wide range of academic initiatives, including international workshops and research projects, carrying out teaching support activities of university courses in the field of urban planning and urban design, and collaborating to the drafting of urban plans for several local municipalities. His scientific interests focus on urban, regional and landscape planning, land take, the recovery of historic centers, ecosystem services, military areas and public real estate. Since 2018, after having been awarded of a scholarship funded by the Department of Civil, Environmental Engineering and Architecture (DICAAR), he is Ph.D. student in Civil Engineering and Architecture at the University of Cagliari. During his doctoral studies, he spent a semester as a visiting researcher in the Netherlands, at the Institute for Housing and Urban Development Studies (IHS) of the Erasmus University of Rotterdam (EUR), a multi-disciplinary research institute at the forefront of the study of urban planning strategies and policies.

His doctoral research, entitled *Planning, regeneration and reuse of public real estate. Guidelines for disposed public properties*, supervised by Prof. Anna Maria Colavitti, focuses on the extent, role and functions of public real estate as a resource in urban regeneration processes, promoting its strategic role to trigger virtuous mechanisms aimed at countering some of the crisis phenomena in contemporary cities. The interest

raised by the topic is given by the uncertainty of the policies developed and the limited consideration of the potential of this resource within the operational practice of spatial planning in the Italian context. These assumptions have led to ineffective processes, as they lack an understanding of the needs and characteristics of the territory, in favor of market-oriented approaches, giving priority to economic and financial aspects. The research aims to define a system of theoretical and operational references to build an urban planning model that integrates public property management into planning practice, in a systemic perspective. The project follows an inductive approach, defining a knowledge framework given the transversality of the research subject, to investigate the relationship between the management of public real estate and urban planning. Particular attention is given to governance and decision-making processes, as well as to the involvement of institutions and different stakeholders, with an emphasis on how the interaction between these actors can contribute to the development of the planning process. From an empirical point of view, the study focuses on the identification of representative case studies, selecting different contexts in which programs and models oriented to the reuse and regeneration of public properties have been applied, analysing their structure, procedures, actors and properties involved, to deepen their relationship with urban regulations and planning tools. On this premises, the research is therefore aimed towards the organisation of a holistic framework, which integrates the potential offered by the availability of public real estate assets within a broader urban development strategy, allowing the definition of a responsible planning process.

Colavitti A.M., Floris A., The enhancement of public real estate as a resource in urban regeneration processes, in Gospodini A. (eds). *Proceedings of the International Conference on Changing Cities IV: Spatial, Design, Landscape & Socio-Economic dimensions*; Chania, Crete Island, Greece, June 24-29, 2019. ISBN: 978-960-99226-9-2.

The reuse of former psychiatric hospitals. A methodological model on design, memory and empathy

Claudia Pintor



Claudia Pintor is an architect and a PhD student in Civil Engineering and Architecture. Her research *The reuse of former psychiatric hospitals. A methodological model on design, memory and empathy* focuses on the reuse of historical asylums, as a model for studying the relationship between design and memory in “the places of suffering”. The investigation is supervised by Prof. Caterina Giannattasio and Prof. Giovanni

Battista Cocco and stands in the disciplinary-scientific area of Restoration and Architectural and Urban Design. It is also conducted with the support of Prof. Donato Severo, pertaining to the multidisciplinary research laboratory EVCAU (EnVironnements numériques, Cultures Architecturales et Urbaines) of Ecole Nationale Supérieure d’Architecture de Paris-Val de Seine, where a semester of study takes place. The Parisian research group boasts several studies on the French hospital system, including psychiatric architecture.

The aim of the study is the enhancement of the historical psychiatric hospitals. The innovative potential of the research is twofold, as there are not only a few studies concerning the intervention on former psychiatric hospitals but also they are in short supply theoretical and operational experiences focused on the effect of memories of suffering in the historical architecture.

The investigation is developed into 3 parts: the first one is dedicated to the relationship between the design and places of suffering; the second part involves deepening the knowledge of the historical asylum; the third one is focused on the exploration of the project of these places. The first part, dedicated to the relationship between design and “plac-

es of suffering”, starts from the definition of this category of artefacts and contexts, then identifies and analyses the case studies, finally defines and exposes the theoretical themes involved, such as stereotypes, prejudices, prosthetic memory – on the fruition side - and materiality / immateriality, dark tourism, *damnatio memoriae* – on the design side. The second part outlines the profile of the historical psychiatric hospital, starting from founding events in nineteenth-century Europe, its social, scientific, ethical motives, how these have been translated into the space, especially the main architectural elements and the typology. A special focus is dedicated to the Italian system, particularly interesting being there over 70 buildings that have lost their mental hospital function following the Legge n.180 / 1978 (so-called Legge Basaglia). A third of these architectures is still, at least in part, abandoned. Also among the refurbished complexes, there are few design practices attentive to the memories of the places. In the third part, these theoretical contributions flow into experimental practices, which are exercised on the former psychiatric hospitals’ Villa Clara in Cagliari, Rizzeddu in Sassari and Ville Evrard in Neuilly-sur-Marne. However, contrary to the Italian ones, the French hospital has been used continuously for residential psychiatric care, so this repertoire allows us to observe the invariant elements of architecture, exploring the psychological relationship that people create with the places that are or have been asylums. The experiments examine the imaginaries that accompany the concept of psychiatric hospital, through collage, and investigate the design by the themes of typology, enclosure, park/garden, pavilions and cells, characterizing the relationship between suffering and asylum architecture.

Highly directive nonlinear micro-structured mechanical system

Anar Rakhimzhanova



My name is Anar Rakhimzhanova, and I am currently PhD candidate in Civil Engineering and Architecture at the DICAAR of the University of Cagliari. I received my Bachelor's and Master's degree in Computer and Mathematical modeling at the Al-Farabi Kazakh National University in Kazakhstan. Afterward, I continued carrying out my research on the project in the field of unbalanced rotor dynamics in inter-

action with other physical fields (Kazakh National University) and at the same time I started working as a Teaching Assistant for university courses. During this period, I completed a 4-months internship by the Erasmus project at the Keele University (UK) in 2017, focusing on the dynamics of an unbalanced centrifuge partially filled with liquid.

The past experiences have motivated me to improve and consolidate my scientific knowledge and later I successfully applied for a Ph.D. position in Cagliari University, Italy. I joined the XXXIV cycle PhD program in Civil Engineering and Architecture in 2018 under the supervision of Prof. Michele Brun and Giorgio Carta, whose works are internationally known in the field of metamaterials.

Metamaterials and functional materials development strategies focus on structures that produce unusual and exotic properties by manipulating waves in ways that have never been naturally possible. They gain their properties not as much from their raw material composition as from their exactly designed structures. The precise shape, size, geometry, orientation, and arrangement of these microstructures affect the waves to create material properties that are difficult to achieve with natural materials. The ability to design and fabricate materials with new functionalities open the door to new possibilities.

The main innovative aspect of my research is the design and analysis of a novel microstructure system which is capable to sustain non-reciprocal wave propagation and extreme wave filtering isolation on the topic “Highly directive nonlinear micro-structured mechanical system”. The unusual effect of the system is achieved by combining the constitutive non-linearity of the material with the momentum displacement induced by the gyroscopic system. Propagation of nonreciprocal elastic waves is investigated analytically and verified numerically. Deep research shows existence of the single waves in the micro-structured system, which are completely determined by the speed of the propagating wave. The developed nonlinear system supports the high direction selective effect. This opens up new possibilities for manipulating nonlinear elastic pulses, since the directions of the transmitted waves can be easily controlled by varying the structural properties of the units. In addition, we demonstrate that the combined effect of the system gives a peculiar form of non-reciprocity in addition to high wave directivity. A system that breaks reciprocity has the capability to transmit the field (in our case stresses and deformations waves) non symmetrically, and this asymmetric transmission offers enhanced control over signal transport, isolation and source protection.

Our results not only show that artificial materials offer a new and rich platform to study the propagation of nonlinear waves, but also opens up opportunities for the design of a new generation of smart systems that take advantage of nonlinearity to control and manipulate the propagation of amplitude vibrations, provide revolutionary solutions to existing problems, and useful tools for future applications.

Women, spaces, power. A nomadic approach to read the urban space

Alice Salimbeni



Graduated in 2018 in Architecture at the Faculty of Engineering and Architecture of the University of Cagliari, with a thesis on the self-construction of an open-air space in the juvenile prison of Quartucciu. Immediately afterwards, she won a PhD scholarship at the Department of Civil, Environmental Engineering and Architecture (DICAAR) and she began to develop a thesis in the disciplines of urban geography,

with a particular focus on gender spatial issues. She spends the academic year 2019-2020 as a visiting researcher at the *Centre de recherches et d'études pour l'action territoriale*, at the *Université Catholique de Louvain* (Belgium). In 2021, she is among the *Emerging Scholar Award Winners* of the international journal *Gender, Place and Culture*. In 2022, she will be part of the international scientific committee of the 6th *European Geographies of Sexuality Conference*, in Barcelona.

Her doctoral research is entitled *Women, Spaces, Power. A nomadic feminist approach to the critical reading of urban space*, supervised by Maurizio Memoli (University of Cagliari), and co-supervised by Elisabetta Rosa (Université Catholique de Louvain) and Barbara Cadeddu (University of Cagliari).

The research focuses on the study of discrimination of cis-gender women in urban space and aims to bring out some mechanisms of socio-spatial inclusion or exclusion and it adopts participatory, visual and creative methodologies. On a theoretical level, the theme of the relationship between women and space is questioned firstly with reference to the literature of feminist geography, which is interested in the political relationship between the social position of women and the way in which this position is translated into an urban issue; secondly

with reference to non-representational theories, which are interested in the relationship between the body and space, with particular attention to the emotional sphere. The aim is to address women's urban experience from the most intimate relationship between body and space to meanings of a political and collective nature. In order to do so, this research also draws on Rosi Braidotti's nomadic feminist theory and, in particular, on the conception of the nomadic subject that she presents. The nomadic subject is a social subject, produced by social phenomena that are "simultaneously external and collective, and intimate" (2011), non-unitary, non-linear, but also interconnected with all other subjects, through power structures. The individual urban experiences of nomadic subjects are significant even though they are special because they are politically and spatially located. Thanks to their specificity and situatedness, they allow us to bring out the schizophrenia of socio-spatial phenomena, the relational plots of the space-time of contemporary cities, and to raise unexpected, sometimes chaotic questions that recall Massey's idea of space as *thrown-togetherness* and *stories-so-far*. In this chaotic idea of urban space, the nomadic theory helps to intercept dynamics of urban exclusion, determined by the spatial socio-cultural conditions.

A participatory fieldwork has led to the production of visual representations (film and photography) that helped in studying these conditions of exclusion, and in making them evident and understandable.

Seaplane stations and historical airfields. Towards possible enhancement and reuse

Monica Vargiu



An Architectural Conservator, she is a PhD student in Civil Engineering and Architecture at the University of Cagliari. In 2009, she obtained a Bachelor's degree in Technology for Conservation and Restoration of Cultural Assets and in 2015 a Master's degree in Conservation of Environment and Architectural Heritage, both with honours. She currently provides teaching support at the Faculty of Engineering and Architecture of the University of Cagliari for the courses Laboratory Restoration, Protection of the Historic Landscape and Theory and History of Restoration, as well as collaborating in research at the DICAAR in the same area: ICAR 19 - Restoration. She focuses on issues of knowledge and valorisation of the historical, cultural and architectural heritage, the study and analysis of historical military assets, with particular reference to those of the 20th century. She also investigates archival documentation, census data as well as cataloguing the implementation of different information systems, including the one provided by MIBACT for the assessment of the cultural interest of architectural heritage. Her PhD research entitled *Seaplane stations and historical military airfields. Methodologies and interdisciplinary tools for the processes of management and the reconversion, valorisation, and dual-use scenarios* (supervised by Prof. Donatella Rita Fiorino) is part of a wider scientific programme carried out by the University of Cagliari in collaboration with the Italian Ministry of Defence, under a general agreement signed by the two institutions (scientific coordinators Prof. Donatella R. Fiorino, Col. Pasqualino Iannotti). In particular, her study focuses on seaplane stations and historical military airfields from the beginning of the twentieth century up to the years immediately preceding World

War II. In summary, the project investigates this widespread and complex military heritage with the aim of reconstructing the wider roles of these historical infrastructures and identifying interdisciplinary methodologies and tools for the processes of management and reconversion, enhancement, and dual-use scenarios. This study aims at documenting the airfields' different typologies and their development over time in their transformations from seaplane stations, and aerodromes to airfields. The evolution of the typologies of flight infrastructures is investigated. Particular attention will also be paid to aspects of the 'contemporary ruin', and to technological artefacts such as hangars, water tanks and wind tunnels that have lost their original function and now are in a state of complete abandonment. Her study aims to compare Italian and UK Heritage, and the different methodologies of investigation and assessment, protection and enhancement put into place by the two cultural agencies. She is currently working as a visiting PhD student for a period of research at the School of Architecture of the University of Portsmouth; her supervisor is Dr Tarek Teba. The research aims to demonstrate the importance of accurate knowledge, and also of deep archival investigation, in order to achieve sustainable reuse of this specialised heritage, both tangible and intangible, in order to offer a guide which identifies sustainable project solutions, which are also respectful of these sites' material authenticity and their historical identity as places.

Fiorino D.R., Vargiu M., Buone pratiche di riconversione e riuso degli aeroporti militari storici: un confronto internazionale | Best practice of reconversion and reuse of historical military airports: an international overview, in: Biscontin G, Driussi G, eds. *Il patrimonio culturale in mutamento. Le sfide dell'uso*, 35° Convegno Internazionale Scienza e Beni Culturali; Bressanone, 15 luglio 2019. Marghera Venezia: Edizioni Arcadia Ricerche Srl, 2019. 785-798



PhD programme in Electronic and Computer Engineering

Coordinator: Alessandro Giua

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.

A total of eleven PhD students have been admitted to the XXXIV cycle which started in 2018 and will end in 2021. Eight students are enrolled at UNICA; a student from Southwest Jiaotong University and two students from Xidian University are enrolled in co-tutorship.

The quality and consistency of the scientific activity is testified by the 25 papers on international journals and the 34 papers on international conferences that the students of the XXXIV cycle have published so far, as part of their doctoral activities.

Electric energy storage systems for the dispatching of renewable sources

Daniele Battaglia

Curriculum: Computer and Systems Engineering



Daniele Battaglia was born in Nuoro, Italy. He received the bachelor's degree in Chemical Engineering and the master's degree in Energy Engineering from the University of Cagliari, Italy, in 2014 and 2018, respectively. Since 2018, he is a Ph.D. student in electronic and computer science engineering with the Department of Electrical and Electronic Engineering, at the

University of Cagliari. The activity research was focused on energy storage systems for the dispatching of intermittent renewable sources, with the supervision of prof. Alfonso Damiano. During my doctoral studies, I had the opportunity to spend my visiting period at The Ohio State University, Columbus, USA, under the supervisor Ph.D. Matilde D'Arpino and prof. Giorgio Rizzoni.

The use of energy storage systems in recent years is becoming increasingly widespread for various reasons from an environmental and energy point of view. Among the various types of energy storage systems, the most widespread are electrochemical systems. In a context of stationary applications, the Sodium Metal Halide Battery (SMHB) has received particular interest in this last period. The presence of specific chemical elements, such as nickel, sodium chloride and iron, make this battery completely recyclable. During the first period of my Ph.D., I was involved in the research activity developed by the Department of Electrical and Electronic Engineering aimed to improve the electrical model reproducing the dynamic behavior of the battery in a wide range of State of Charge (SoC). The proposed model has been experimentally validated. A second-order model has been obtained for SoC values from 90% to 10%, both in the charge and discharge phase.

It was estimated that with the proposed model, the modeling error across the SoC range has relative percentage errors of less than 1%.

During my period at Ohio State University, I was involved in the Second Life Battery, i.e., the reuse of storage systems after they have lost their useful life for their main application. In fact, lithium-ion batteries that have lost as little as 20% of their initial capacity are often withdrawn from EV application and sent to battery recycling plants. Such batteries would still be able to provide services for stationary applications, minimizing the environmental impacted cost of recycling. The daily power profiles of stationary applications, such as frequency regulation and DC fast charging, and their impact on second-life batteries were evaluated. Using an empirical aging model that evaluates the calendar and cycling effects, the lifespan of the batteries for the previously mentioned applications was assessed. Using specific statistical metrics, it was possible to evaluate the degree of replacement of the batteries on a forecast basis. The final goal was to develop a general methodology for analyzing the power profiles associated with SLB applications.

Battaglia D., *et al.*, Impact of Power Profile on the Estimation of Second Life Batteries Remaining Useful Life, *SAE Technical Paper* 2021-01-0767 (2021)

Malware analysis and detection in personal devices and networks

Fabrizio Cara

Curriculum: Computer and Systems Engineering



I received the B.S. in Computer Engineering in 2016 and the M.S. in Telecommunications Engineering “cum laude” in 2018 at the University of Cagliari. In 2018, I collaborated with the Pattern Recognition and Applications Lab (PRALab) at the University of Cagliari as a research scholarship holder. Then in late 2018, I started my Ph.D. program at the University of Cagliari with the Computer Security team within the PRALab, under the supervision of Prof. Giorgio Giacinto. My research field is Computer Security. More specifically, my focus is on analyzing malicious behaviors in a broad range of systems, such as mobile platforms (Android), computer platforms (Windows and Linux), and Internet of Things devices. In line with that, during my Ph.D. program, I spent six months at the Georgia Institute of Technology (Atlanta, Georgia, USA) to deepen my knowledge of Internet of Things and network security.

My research goal is to better understand how malicious attacks are perpetrated and how it is possible to mitigate them. Therefore, moved by multiple security reports, I started to investigate the phenomenon of malicious attacks perpetrated with Microsoft Office files in Microsoft Windows platforms. These files are particularly effective in attacking Windows devices because users do not associate these formats with potential threats. A Microsoft Office file is a set of information with a predefined structure, which includes mostly text, images, tables, and graphs. Moreover, these files typically use a custom programming language that allows attackers to hide the malicious content in a specific section of the Office file called macro. After acknowledging this threat and understanding how to detect the malicious content, I developed a

system called Oblivion. This system is capable of analyzing Microsoft Office files (Word and Excel, which are the most used) to retrieve the most information possible, such as the attack code, the interactions with the attacked system, possible Internet connections with remote devices, etc. Thanks to this work, I have the possibility to give my contribution on how to mitigate the attacks perpetrated with Microsoft Office files, which nowadays are one of the most used ways to perform a vast kind of cyberattacks.

During my Ph.D. program, I also focused on Android security. Android is the most used operating system for mobile platforms in the world. Moreover, it is also the most targeted by attackers. On this topic, I published a scientific paper on how much robust antivirus systems based on machine learning are and how difficult it is to fault these systems. The goal of this research project is to design and develop a system capable of creating malicious applications that are wrongly identified as trustful ones by a specific antivirus system based on machine learning. As described in the publication cited below, using a well-known adversarial machine learning attack, called evasion attack, I designed a system capable of performing specific manipulations to a set of malicious Android applications. These precise manipulations allow the creation of an evasive malware sample. So, even if this application is a malicious software, it is classified as a benign one so that it can perform the attack for which it has been designed. Evaluating the system, I found that an attacker can create such evasive malicious Android applications with very low knowledge of the target antivirus system and low effort.

All my research work performed during my Ph.D. program can be found in my Ph.D. thesis, entitled “Malware Analysis and Detection in Personal Devices and Networks”.

Cara F., *et al.*, On the Feasibility of Adversarial Sample Creation Using the Android System API, *Information* 11.9: 433 (2020)

Non-standard operators for CNN HW accelerators on FPGA.

Marco Carreras

Curriculum: Electronics and Telecommunications



Marco Carreras received his Master's degree in Electronics Engineering from the University of Cagliari, in 2018, with the thesis *"Support for 8-bit data representation in Convolutional Neural Networks acceleration on FPGA: NEURAghe architecture integration"*. In October 2018 he started his PhD in Electronic and Computer Engineering under the supervision of Prof.

Paolo Meloni. In 2021 he worked with the Digital Circuits and Systems group led by Prof. Luca Benini, (IIS, ETH Zurich), as visiting PhD Student.

His research interests involve the development and optimization of Convolutional Neural Network's uncommon operators for machine learning hardware accelerators on Field-Programmable Gate Array (FPGA) devices suitable for edge applications.

Convolutional Neural Networks (CNNs) are a class of Deep Feedforward Artificial NN that is composed by a concatenation of multiple layers applying different operators (convolution, pooling, ReLU, FC, etc.) to data from input to the outcome. Most of the computation workload in CNNs is dedicated to multiply-and-accumulate operations in convolution and fully connected layers. This kind of operations can be mapped very effectively on Digital Signal Processing slices that are available in modern FPGA devices. This makes FPGAs a very promising technology substrate for the implementation of CNN hardware accelerators.

In recent years CNNs have been extensively used in a wide range of computer vision tasks like image classification, recognition, and segmentation. Their widespread use combined with their high computational load has led researchers to extensively work on the

development of hardware accelerators for CNN inference. Among different solutions, FPGA-based architectures, in an embedded near-sensor scenario, has become of considerable importance. Along with computer vision ones, CNNs have begun to grow in interest also for applications that were commonly the domain of different algorithms. Sequence modelling task is an example where Recurrent Neural Networks can be easily replaced with CNNs referred to as Temporal CNN or TCN, raising the question if such an implementation can be efficiently accelerated in FPGA-based architectures. With this aim, Carreras et al. show a methodology for optimal execution and data-transfers scheduling that exploits sequence-based TCN structure and also how a CNN inference accelerator could be enriched to provide needed flexibility (e.g. support for dilated convolutions).

Even more recent approaches for edge-oriented and mobile applications seek to reduce the number of network parameters, i.e. its memory footprint, fostering the development of different types of convolution schemes like depthwise separable convolutions, often arranged in bottleneck (MBConv) layers. The exploration of how an FPGA-based MBConv-oriented hardware accelerator can be implemented and how such specificity can outperform a more general commercial solution (Xilinx DPU) was the aim of the subsequent part of the PhD work.

The period abroad offered the opportunity to work on the FPGA integration of a Spiking Neural Network (SNN) Engine (SNE) to efficiently accelerate SNN inference tasks at the edge. SNNs are a NN category where each neuron activation depends on a threshold resulting in a perfect candidate to the event-based sensors data processing as they show an accuracy level comparable with state-of-the-art NN while reducing the number of required operations.

Carreras M., *et al.*, Optimizing Temporal Convolutional Network Inference on FPGA-Based Accelerators, *IEEE Journal on Emerging and Selected Topics in Circuits and Systems* 10(3): 348-361 (2020)

Cyber security of Discrete Event Systems

Chao Gao

Curriculum: Computer and Systems Engineering



I started my PhD in 2017 at Xidian University with the System Control and Automation Group under the supervision of Prof. Zhiwu Li. In 2018, I enrolled at the University of Cagliari in co-tutorship under the supervision of Prof. Alessandro Giua and Prof. Carla Seatzu. From 2018 to 2020, I spent visiting periods at DIEE for 21 months and had the chance to collaborate

with skilled professors, researchers, and PhD colleagues.

My research interests focus on the cyber-security of discrete event systems. Cyber-physical systems (CPSs) have emerged as a key technology for developing autonomous distributed control systems. However, they are particularly exposed to attacks from malicious intruders, which may pose severe threats to critical infrastructures and even lead to a system-wide standstill. CPSs can be described by abstract models for the study of problems concerning their logical behavior. Among these models, we considered discrete event systems (DESs) whose state space is a discrete set, where event occurrences cause transitions from one state to another.

We notice that, due to facts such as limitation and failure of sensors, unstable network, and cyber-attacks, it happens that both certain events of a system and attacks are unobservable. Taking those facts into account, we focus on partially observed DESs, which involve both logical DESs (that consider only the order in which event occurs) and timed DESs (that also specify the time structure).

One of my research topics is in terms of logical DESs. The research considers an *attack dictionary*, which maps an observable event into a set of corrupted strings. An observation of a plant may be corrupted by an attack (function) over an attack dictionary. We assume that a

system may be subject to multiple types of attacks, each of which is described by its own attack dictionary. Furthermore, we distinguish between *constant attacks* that corrupt observations by using only one of the attack dictionaries, and *switching attacks* that may use different attack dictionaries at different steps. We address the problem of detecting if a system has been attacked and, if so, which attack dictionaries have been used. To solve this problem, we construct a new structure that describes the observations generated by a system under attack: in particular, different structures correspond to a system subject to a constant and to a switching attack. In conclusion, the problem of attack detection can be reduced to a classical problem of *state estimation* or *fault diagnosis* for these new structures.

In addition, my research also concerns timed DESs, where a class of timed automata is characterized by a single clock that is reset to zero after each event occurrence. A time interval is associated with each transition to specify when it may occur. As an intermediate step to investigate cyber security problems, this research currently aims at estimating and updating the set of states consistent with the whole observation, considering the information coming from the observation of new events at particular time-instants. The proposed solution is based on a partition of the clock values at a state into *zones*. We then construct a *zone automaton* that provides a purely discrete description of the considered timed automaton. The problem of investigating the reachability of a state in the timed automaton is reduced to the reachability analysis of a state in the associated zone automaton. As future works, we are investigating the cyber security problems of timed automata. In particular, we plan to study under which conditions one can detect an attack in a given time interval: this is a problem of great interest for real-time systems.

Gao C., *et al.*, A region-based approach for state estimation of timed automata under no event observation, *IEEE International Conference on Emer Tech and Fact Auto*, Vienna, Austria, 2020, pp. 799–804. IEEE (2020)

Non-blockingness verification and supervisory control of Petri nets

Chao Gu

Curriculum: Computer and Systems Engineering



I received my B.S. degree in Automation from North China Electric Power University, China, in 2014 and my M.S. degree in Control Engineering from Xidian University, China, in 2017. I am currently in a Ph.D. programme in co-tutorship between Xidian University, China, and the University of Cagliari, Italy, under the supervision of Prof. Alessandro Giua

and Prof. Zhiwu Li. During my doctoral studies, I visited the group of Automatica in DIEE, University of Cagliari, Italy, for 18 months. The group is vibrant and has a strong academic atmosphere, which deeply inspires me to delve into my research topic. I am grateful that I had the chance to work and interact with all the skilled Professors, researchers, and PhD colleagues. In particular, I want to thank Prof. Alessandro Giua, who patiently guides me on doing excellent research and constantly encourages me to build up a better character.

My research mainly focused on the analysis and control of Petri-net-based discrete event systems. The title of my Ph.D. thesis is “*Non-blockingness verification and supervisory control of Petri nets using semi-structural approaches*”. In general, discrete event systems (DESs) are event-driven systems whose state space can be described as a discrete set. As a mathematical characterization for studying, modelling, and analyzing DES, Petri nets offer various vantages over automata. For instance, states in Petri nets can be represented as vectors, namely markings; ergo, techniques such as linear algebra can be applied. On the other hand, structural-based approaches can be adopted to avert exhaustively enumerating the state space, therefore mitigating the state explosion problem. In DESs, non-blockingness is a property that ensures that all pre-specified tasks can be completed, which is

a mandatory requirement during the system design stage. Given its importance, two problems regarding non-blockingness are mainly considered, i.e., how to verify the non-blockingness of a given system efficiently (the verification), and for a verified blocking system, how to synthesize an online control agent (e.g., a supervisor) ensuring that the controlled system remains nonblocking (the enforcement). Recently, a semi-structural analysis technique in Petri nets, called the basis reachability analysis, was proposed. In such an approach, an automaton-like structure called basis reachability graph (BRG) is constructed.

During my Ph.D., I worked towards the non-blockingness verification and enforcement problem by using the BRG-based approaches. In the following, we only introduce the results presented in Gu et al. (2021). In Gu et al. (2021), we introduce a particular type of BRGs called conflict-increase BRGs (CI-BRGs) that encode sufficient non-blockingness-related information by referring to a particular partition of the transition set. Differently from a variant of BRG namely minimax-BRG that we previously proposed, a CI-BRG is identical in essence with BRG. We characterize the main properties of basis markings in CI-BRGs and prove that the non-blockingness of a system can be verified by checking if all basis markings in its corresponding CI-BRG are non-blocking.

Although there exist restrictions on obtaining of CI-BRGs in Gu et al. (2021), which depend on the system structure and the parameters of the linear constraint that describes the final markings set, thanks to the compactness of BRGs, our approach still achieves practical efficiency compared with the reachability-graph-based analysis since the exhaustive enumeration of the state space can be avoided. In particular, our method does not require that the net is deadlock-free.

Gu C., *et al.*, Non-blockingness verification of bounded Petri nets using basis reachability graphs, *IEEE Control Systems Letters* 6: 1220-1225 (2021)

Verification and Application of Detectability based on Petri Nets

Hao Lan

Curriculum: Computer and Systems Engineering



I received the B.S. degree in automation from Southwest Jiaotong University, Chengdu, China, in 2016. Now, I am a PhD student in cotutorship between Southwest Jiaotong University and the University of Cagliari. I am currently pursuing the Ph.D. degree in Traffic Information Engineering and Control at Southwest Jiaotong University, China, under the supervision of Prof. Jin Guo, and in Electronic and Computer Engineering at University of Cagliari, Italy, under the supervision of Prof. Carla Seatzu. My current research interests include Petri nets, state estimation, detectability and opacity in discrete event systems.

My research interests mainly focused on the state estimation and analysis of discrete event systems. The title of my PhD thesis is "*Verification and Application of Detectability based on Petri Nets*". Petri nets are a graphical and mathematical modeling tool with a higher modeling power than finite state automata. Furthermore, using structural analysis and algebraic techniques, a series of problems can be solved more efficiently using Petri nets. In many rail-word systems, due to the limitations of sensors or the constraints of the environment, the system dynamic is usually not perfectly known. However, it is always necessary to determine the state information of the system in many applications such as fault diagnosis, state-feedback control, opacity, etc. Recently, the state estimation problem has been studied systematically in the framework of detectability. The detectability properties characterize the possibility to determine the current and the subsequent states of a system after the observation of a finite number of events generated by the system. As an important property in the class of state estimation problems, detectability is closely related to many

security / privacy properties, e.g., diagnosability, opacity, observability. Therefore, in my thesis, we study the detectability of systems using Petri nets where some events are unobservable. More precisely, the definition of the detectability properties in Petri net framework and the detectability verification problem are considered. Given a system, the detectability verification problem consists in determining whether the system satisfies any detectability properties.

One of my research topics during PhD is the verification of C-detectability using Petri nets. Detectability requires that the current and the subsequent states always have to be determined without uncertainty. Imposing detectability could be rigorous in some real applications, since it typically requires a huge number of sensors associated with transitions. In our work, we propose different notions of detectability. In particular, we formalize the notion of C-detectability, where “C” stands for “crucial”. C-detectability requires that if the set of markings consistent with a certain observation contains crucial states, then the crucial state has to be determined uniquely after a finite number of observations. In other words, we extend detectability to C-detectability that only requires that a given set of crucial states can be distinguished from the other states. In more detail, four types of C-detectability are defined. Clearly, detectability is a special case of C-detectability, where the set of crucial states is equivalent to the whole state space. Moreover, we propose efficient approaches to verify such properties in the case of bounded labeled Petri net systems. The proposed approaches use the notion of basis marking and thus do not require an exhaustive enumeration of the reachability space.

Lan H., *et al.*, Verification of C-detectability using Petri nets, *Information Sciences* 528: 294-310 (2020)

RF modeling, design, characterization, and biomedical applications of magnetic scaffolds

Matteo Bruno Lodi

Curriculum: Electronics and Telecommunications



Matteo Bruno Lodi was born in Cagliari in 1994. He received the bachelor's degree in biomedical engineering from the University of Cagliari, Cagliari, in 2016, and the master's degree in Biomedical Engineering from Politecnico di Torino, in 2018. He started his PhD in 2018, under the supervision of Prof. Giuseppe Mazzeo and Prof. Alessandro Fanti, within the group of Elettromagnetismo Applicato. His research activity deals with the modeling of bio-electromagnetic phenomena. During the three years of PhD, he focused on the study, manufacturing, modeling and characterization of magnetic biomaterials for biomedical applications. He was awarded as Young Scientists at the General Assembly and Scientific Symposium of URSI in 2020 and 2021.

Magneto-responsive biomaterials, called magnetic scaffolds, are polymers, bioceramics or composite which are chemically doped with magnetic ions (e.g., Fe, Ni) or loaded with magnetic nanoparticles. The magnetization turns a passive prosthetic implant into a third-generation, active and smart medical device, which can be remotely controlled by an external radiofrequency magnetic field to trigger a desired biological reaction. Magnetic scaffolds can be used for several biomedical applications. By implanting this innovative type of magnetic biomaterials, it is possible to open new therapeutic possibilities against bone cancers. Indeed, after the resection of bone cancers, a magnetic scaffold can be implanted to sustain the tissue growth, while, after the exposure to a radiofrequency magnetic field, it is possible to perform the hyperthermia treatment and control the tumor recurrence rate, enhancing the effectiveness of radio- and chemotherapy. The administration of therapeutic heat through the

local dissipation offers noticeable advantages (e.g., reduced number of hot spots, post-operative management) with respect to other treatment modalities, such as radiative hyperthermia. Furthermore, the magnetic scaffolds can be used as the core-element of a magnetically targeted drug delivery system for bone repair and regeneration.

In his thesis work entitled “*RF Modeling, Design, Characterization and Biomedical Applications of Magnetic Scaffolds*”, after having recognized the lack of an engineering perspective for driving the manufacturing and characterization of magnetic scaffolds for therapeutic applications, the design requirements were derived by the development of innovative multiphysic mathematical models. In this framework, the design of ferromagnetic 3D-printed, biomimetic architecture based on triply periodic minimal surfaces was carried out. Then a thorough experimental characterization of their hyperthermia potential at radiofrequency was performed in (a remote) collaboration with the Magnetic Nanostructure Characterization, Technology & Applications from the Aristotle University of Thessaloniki. Furthermore, the influence of the processing and manufacturing parameters on the therapeutic performance was assessed combining TeraHertz (THz) Radio-tomography and numerical simulations of a set of polymeric scaffolds, magnetized through a modified drop-casting method. Finally, with the knowledge and insight gained, the feasibility and the potential of using magnetic scaffolds as part of new drug delivery strategy for bone repair was investigated in silico with a unique model.

Lodi M.B., *et al.*, A multiphysic model for the hyperthermia treatment of residual osteosarcoma cells in upper limbs using magnetic scaffolds, *IEEE J Multisc Multiph Comp Tech* 4: 337-347 (2019)

Towards Debugging and Improving Adversarial Robustness Evaluations

Maura Pintor

Curriculum: Computer and Systems Engineering



Maura Pintor was born in Cagliari. She received the MSc degree in Telecommunications Engineering with honors in 2018, from the University of Cagliari (Italy) discussing a thesis titled “A novel temporal descriptor for analyzing small and large crowds by computer vision algorithms”. Her research interests include adversarial machine learning and machine-

learning explainability methods, with applications in computer vision and cybersecurity. She has been working on such topics since 2018 under the supervision of Battista Biggio and Fabio Roli. She was a visiting student at Eberhard Karls Universität Tübingen (Germany), from March to June 2020, under the supervision of Wieland Brendel, and virtually at Software Competence Center Hagenberg (Austria) from May to August 2021, under the supervision of Werner Zellinger.

Despite exhibiting unprecedented success in many application domains, machine-learning models have been shown to be vulnerable to *adversarial examples*, i.e., maliciously perturbed inputs that are able to subvert their predictions at test time. These adversarial perturbations are optimized via gradient descent, minimizing a loss function that amounts to increasing the probability of misleading the model’s predictions. To counter such attacks, machine-learning model designers test their models against such worst-case adversarial perturbations and aim to build defense mechanisms that mitigate their impact. However, many of the proposed defenses have been shown to provide a false sense of security by causing gradient-based attacks to fail, rather than really improving machine-learning models’ robustness to attacks. They have been indeed broken under more rigorous evaluations. Although guidelines and best practices have been suggested to improve current

adversarial robustness evaluations, the lack of automatic testing and debugging tools makes it difficult to apply these recommendations in a systematic and automated manner.

To overcome these issues, during her PhD, Maura Pintor provided the following two main contributions, as also described in her PhD Thesis, titled *"Towards Debugging and Improving Adversarial Robustness Evaluations"*. First, she developed a novel attack, referred to as *Fast Minimum-Norm (FMN)* attack, which competes with state-of-the-art attacks in terms of quality of the solution, while outperforming them in terms of computational complexity and robustness to sub-optimal configurations of the attack hyperparameters. These are all desirable characteristics for robustness evaluation, as the aforementioned problems often arise from the use of sub-optimal attack hyperparameters, including, e.g., the number of attack iterations, the step size, and the use of an inappropriate loss function. Second, she proposed a framework that helps debug the optimization process of adversarial examples, by means of quantitative indicators that unveil common problems and failures during the attack optimization process. Using such indicators, specific mitigation strategies can help avoid the common pitfalls encountered in state-of-the-art adversarial robustness evaluations of machine-learning models, hence providing a first concrete step towards improving the reliability of such evaluation processes and designing more trustworthy machine-learning technologies.

Pintor M., *et al.*, Indicators of Attack Failure: Debugging and Improving Optimization of Adversarial Examples, ArXiv preprint (2021)

Coordination of open multi-agent systems

Zohreh Al Zahra Sanai Dashti

Curriculum: Computer and Systems Engineering



Zohreh Al Zahra Sanai Dashti was born in Tehran, Iran. She received the B.S. and M.S. degrees in Electronic and Mechatronics Engineering from Qazvin Islamic Azad University, Iran, respectively in 2010 and 2013. Since October 2018, she has been pursuing a PhD degree at the Department of Electrical and Electronic Engineering of the University of Cagliari, under the supervision of Prof. Mauro Franceschelli and Prof. Carla Seatzu. She spent a visiting period at the Technical University Berlin (TUB), Berlin, Germany, under the supervision of Prof. Jörg Raisch. During the three years of the PhD program, she attended courses in Italy, Germany, and France, dealing with discrete event systems, distributed coordination of multi-agent systems, multi-agent distributed optimization and learning over wireless networks.

Her research interests mainly include multi-agent systems, consensus protocols, and finite time consensus. The focus of her PhD thesis is the *"Coordination of Open Multi-Agent Systems"*. A Multi-Agent System (MAS) is a large set of dynamical systems (agents) which interact within a network. One of the most investigated problems in this area is the consensus problem, i.e., the design of a distributed control strategy to drive the state variables of each agent to the same value. MASs are used to model several networks of systems such as multi-robot systems and sensor networks which interact over a communication or sensing network. The consensus problem becomes more challenging in the presence of agents that can join and leave the network, thus the name "open" multi-agent systems. This topic is recent in the scientific literature and quickly gaining attention. Motivated by this, she focused

her attention on the consensus problem on the median value and consensus on the average in open multi-agent systems.

Thus, as a first result, a novel distributed open average consensus protocol for multi-agent systems has been proposed. The distributed algorithm tracks the average of the agents' state despite the time-varying size and composition of the network. The research activity consisted in the design and formal characterization of the convergence properties of the algorithm. The results have been corroborated by numerical simulations.

As a second result of the research activity has been the characterization of the convergence properties of a distributed algorithm to compute and track the median value of a set of numbers in an open multi-agent system has been proposed. A continuous time formulation was considered where the state variables of the agents track with zero error the median value of a set of time-varying reference signals given as input to the agents in a time-varying, undirected network topology. The performance of the proposed protocol was considered in the framework of open multi-agent systems by proposing join and leave mechanisms, i.e., the scenario where agents may join and leave the network during the protocol execution. One notable feature of consensus on the median value is the robustness of the median value, as opposed to the average value, with respect to abnormal or outlier state values. Non-smooth Lyapunov theory was employed to provide convergence guarantees and simple tuning rules to adjust the algorithm parameters. Part of the results of this research are published in Sanai Dashti et al. (2019).

Sanai Dashti Z.A.Z., *et al.*, Dynamic consensus on the median value in open multi-agent systems, in *2019 IEEE 58th Annual Conference on Decision and Control (CDC)*. IEEE, 2019, pp. 3691–3697

Runtime adaptive cognitive IoT nodes for healthcare monitoring

Matteo Antonio Scrugli

Curriculum: Electronics and Telecommunications Engineering



He received his master's degree with honor in 2018 at the University of Cagliari, with the thesis "Adaptive Runtime Manager for low-power microcontroller-based IoT nodes". He is currently pursuing a Ph.D. degree in electronic engineering at the University of Cagliari at the DIEE department. In 2021 he begins a collaboration with dr. Bojan Blažica (Jožef Stefan

Institute) as a visiting Ph.D. Student.

His research mainly concerns the development of systems capable of managing at runtime the hardware and software configuration of low-power devices in order to adapt it to the required operating mode. Recently, the work is focused on cognitive IoT devices, based on single-core or multi-core platforms, capable of enabling cognitive edge-computing.

The Internet of Medical Things (IoMT) paradigm is becoming mainstream in multiple clinical trials and healthcare procedures. It relies on novel very accurate and compact sensing devices and communication infrastructures, opening previously unmatched possibilities of implementing data collection and continuous patient monitoring. Nevertheless, to fully exploit the potential of this technology, some steps forwards are needed. First, the edge-computing paradigm must be added to the picture. A certain level of near-sensor processing has to be enabled, to improve the scalability, portability, reliability, responsiveness of the IoMT nodes. Second, novel, increasingly accurate, data analysis algorithms, such as those based on artificial intelligence and Deep Learning, must be exploited.

To reach these objectives, designers, programmers of IoMT nodes, must face challenging optimization tasks, in order to execute fairly

complex computing tasks on low-power wearable and portable processing systems, with tight power and battery lifetime budgets.

During the Ph.D. studies, cognitive data analysis algorithms have been implemented on resource-constrained computing platforms. To minimize power consumption, an adaptive firmware layer has been added, that dynamically manages frequency and power supply, as well as software task execution. Using this later, the system optimizes energy consumption at runtime, adapting to data-dependent workload and to flexible operating mode, featuring different analysis detail levels.

This approach has been validated on a use-case using a convolutional neural network to classify electrocardiogram (ECG) traces on a low-power microcontroller. Experimental results show that adapting the node setup to the workload at runtime can save up to 50% power consumption and a quantized neural network reaches an accuracy value higher than 98% for arrhythmia disorders detection on the MIT-BIH Arrhythmia dataset.

The runtime reconfiguration system has also been tested in low-power multi-processor platforms; it has been shown that dynamic management of the resources (cores) leads to a reduction in consumption of 15% compared to static management.

During the period abroad, the system mentioned above was tested in a different use case, namely the movements or exercises recognition through neural networks detected during the use of a balance board.

Scrugli M.A., *et al.*, An adaptive cognitive sensor node for ECG monitoring in the Internet of Medical Things, arXiv-prints, p. arXiv: 2106.06498 (2021)

Data traffic analysis to monitor and understand the people's mobility in Smart Cities

Marco Uras

Curriculum: Computer Engineering and Telecommunication



Marco Uras is a Telecommunications Engineer and in 2018 he started his PhD in Electrical, Electronic and Computer Engineering at the University of Cagliari. The topics covered during his research work are related to Data Science and Internet of Things technologies with particular application to Smart City's needs. In 2015 he started dealing with software development in the mobility field, and since 2016 he works at the Net4U Laboratory of the Department of Electrical and Electronic Engineering of the University of Cagliari. Furthermore, Cloud Computing, Artificial Intelligence and their applications in the Smart Cities field are additional research interests.

The Smart City area is an abstract projection of future communities, a virtual fence defined by a set of needs that find answers in technologies, services and applications which can be traced back to different domains: smart building, inclusion, energy, environment, government, living, mobility, education, health, and much more. In general, the smart city concept involves different ICT technologies and several physical devices which are connected to the Internet of Things to optimize the efficiency of city services and with the objective to improve the quality of life of the citizens.

A UN report states that in 2030, about 70% of the total world population will live in cities. This increases the complexity of the services that the local public administrations must provide the citizens. For an appropriate design, deployment and management of these services, there is the need for tools to extract data on how the people move and which activities they conduct (in an anonymous way). As a challenging task, this need has triggered extensive research

in the last decade, with major solutions that rely on analyzing traces of network traffic generated by citizens' Wi-Fi devices, analyzing Open Data on traffic flows provided by municipalities and analyzing Call Data Records provided by Telecom operators. However, one major approach relies on catching the signals sent by devices during WiFi networks discovery, basically exploiting a global unique identifier of the device called MAC address, which allows for counting the number of people in each area. This approach has been a solid solution until some manufacturer introduced the MAC address randomization process to improve the user's privacy.

During the PhD, he collaborated in the project Monifive funded by the Italian Ministry for the Economic Development (MISE), under the framework "Asse II del programma di supporto tecnologie emergenti (FSC2014-2020)", developing the prototype of People Mobility Analytics (PmA) solution. The PmA system collects and analyzes heterogeneous data types, mainly probe requests generated by Wi-Fi devices considering the randomization of MAC addresses. Moreover, the PmA system processes the collected data to extract key insights on the people's mobility, such as: crowd density per area of interest, people flow, time of permanence, heat maps, origin-destination matrices and estimation of people positions. The major novelty with respect to the state of the art is related to new powerful indicators that are needed for some key city services, such as security management and people transport services. The experimental activities were carried out in real scenarios in collaboration with Municipalities and Public Transport companies and are explained in his PhD thesis: *"Data traffic analysis to understand the people's mobility in Smart Cities"*

Uras M., *et al.*, PmA: A real-world system for people mobility monitoring and analysis based on Wi-Fi probes, *Journal of Cleaner Production* 270: 122084 (2020)



PhD programme in Industrial Engineering

Coordinator: Francesco Aymerich

The PhD programme in Industrial Engineering aims at providing doctoral level 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 that of training highly qualified researchers and professionals, capable of carrying out, working both independently and within a team, original and innovative research, and of 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, knowledge, skills, and competencies required to meet the challenges and opportunities of the current industrial progress in the international context. The path of the doctoral candidates includes the attendance to advanced courses and lectures organised by the PhD programme, the participation in workshops and summer/winter schools, the dissemination of the results of their research through 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 XXXIV 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 that include the application of modelling and monitoring techniques for the analysis of power systems or composite structures, the optimization of aeronautical components and renewable energy devices, the development of ICT platforms for waste management programs.

<https://dottorati.unica.it/ingegneriaindustriale/>

Numerical and experimental analysis of OWC systems with Wells turbine

Fabio Licheri



Fabio Licheri was born in Oristano in 1992. He graduated in Mechanical Engineering in 2018 at the University of Cagliari, with a master thesis titled *“Design of a Wells turbine with active pitch-controlled blades”*. His studies have been mainly focused on the field of turbo-machinery, both with experimental and numerical approaches. He started his Ph.D. in Industrial Engineering

in 2018, after a short training period of four months at the University of Oxford (UK) where he had the opportunity to work at the Osney ThermoFluids Institute (OTI). During this period, he designed a blade row for an experimental set-up used to investigate the flow field and heat transfer in nozzle guide vanes of industrial gas turbines. He spent additional seven months at the OTI in 2020 where he was involved in the design of a new methodology and facility for Thin Film Gauge calibration.

His Ph.D. thesis is titled *“Numerical and experimental analysis of OWC systems with Wells turbine”*. Among all the renewable energy sources, ocean energy shows a strong potential and Oscillating Water Column (OWC) devices are simple and reliable solutions to harvest and convert wave energy into electrical energy by coupling with Wells turbines. These turbines present a very simple geometry but their unusual configuration with respect to conventional turbomachines complicates the study and prediction of their performance. Investigations on Wells turbine global performance have been conducted by several authors in the last four decades, both numerically and experimentally, but only a few investigated the detailed flow field around the machine.

The work conducted during Fabio’s Ph.D. thesis investigates the local flow field around a Wells turbine in order to locally characterize

the machine performance leading to the aerodynamic optimization of turbine's blades.

Numerical analyses have been conducted by means of Computational Fluid Dynamics (CFD), by means of conventional and innovative approaches where the entropy evaluation method has been used to compare the performance of different Wells turbine geometries, with particular emphasis on the estimation of their efficiency.

Experimental analyses have been conducted on a set-up housed in the Department of Mechanical, Chemical and Materials Engineering which simulates an OWC system coupled with a Wells turbine. The prototype scale of the set-up and the non-stationary nature of the flow that affects the turbine make aerodynamic measurements challenging. For these reasons, aerodynamic probes have been designed, built and used specifically for the tested set-up. Several turbine geometries have been characterized and compared under different flow conditions simulating several sea-wave states. Control strategies have been studied and carried out experimentally in order to extend the working range of the Wells turbine and increasing its performance.

Licheri F., *et al.*, A Comparison of Different Approaches to Estimate the Efficiency of Wells Turbines, *Journal of Fluids Engineering* 143: 051205 (2021)

Structural health monitoring & damage detection in composite materials

Gabriela Loi



I am Gabriela Loi and I am attending the XXXIV PhD cycle in Industrial Engineering at the University of Cagliari, with a focus on Structural Health Monitoring and impact damage detection in composite materials. My research experience began in 2012 developing my B.Sc. thesis based on simultaneous subsurface defect detection and contact parameter analysis in a wheel-rail system by means of one of the primary non-destructive testing techniques: ultrasonic waves. In 2017 I joined the Material Testing Laboratory to work on my M.Sc. thesis which consisted in a numerical analysis of the flexural response of ferro-cement samples. During my university carrier I have always shown interest in the field of research in material testing and characterization. Therefore, I started my career as a doctoral student at the PhD course in Industrial Engineering in October 2018.

In these three years I carried out a research titled Structural Health Monitoring and damage detection in composite materials and structure. Composite materials have been widely used in many advanced engineering applications due to the several advantages they offer over more conventional materials, such as high specific strength, great flexibility in design and resistance to fatigue and corrosion. Nevertheless, their high susceptibility to impact damage is one of the biggest concerns for their use in critical load bearing applications. Therefore, there is a need for efficient damage detection techniques that can be applied to these complex materials. During the last decades, many non-destructive testing (NDT) techniques that can be applied to structural composites were developed, including those based on the analysis of linear and nonlinear acoustic phenomena. Among them,

special attention was given to three different techniques to further assess their effectiveness and applicability to composite materials. Firstly, the Scaling Subtraction Method (SSM) is an approach used to extract nonlinear features of an acquired signal generated by the response of a system to an impinging wave, to reveal effects that can be associated to internal damage. The SSM has been applied to examine the response of laminated composite beams to the presence of damage induced by low-velocity impact under different types of excitations. Then, the focus was paid to the concept of Local Defect Resonance (LDR) that carries the promise to improve the efficiency and sensitivity of the damage detection process. Structural defects produce local stiffness loss that results in the appearance of characteristic resonant frequencies, known as the LDRs, at the damaged areas. The mode shapes related to these local resonances can be observed in the out-of-plane as well as in the in-plane directions. One of the biggest concerns related with the practical use of the LDR approach as a non-destructive testing technique is the identification of the local resonance of the defect among the natural frequencies of the system. In particular, this specific non-linear effect was deeply investigated during the period abroad at AGH University of Science and Technology in Krakow (Poland) under the supervision of Prof. Lukasz Pieczonka at the Department of Robotics and Mechatronics. Come back to Cagliari due to Covid emergency, I focused on the study of nonlinear vibro-acoustic modulation effect, which is the result of the interaction of two waves of different frequency that travel within the material.

The decision to enroll in a PhD program always come from the will to learn, your curiosity as well as the need for a challenge. And this is exactly what these three years have been. The PhD at University of Cagliari allowed me to gain a wealth of knowledge, to spend a period in an internationally recognized laboratory, which results in the opportunity to collaborate with a high-level research team, as well as to look forward for the opportunity to keep on making research in this field.

Analytical model for GaN HEMTs in high frequency /high voltage applications

Paolo Pirino



Paolo Pirino received his Master's Degree in Civil Engineering from University of Cagliari in 2013. Since 2018 he is a PhD student in Industrial Engineering at the Department of Electrical and Electronics Engineering in Cagliari within the Power Electronics group.

The research activity during the PhD is focused on the modeling of wide-bandgap power devices, especially GaN high-electron-mobility transistor (HEMT). It is well known that the improvements of the power electronic converter performance, in terms of power density and efficiency, strictly depends on the semiconductor switch performance. Silicon semiconductors have long been the dominant choice for medium and high voltage switching applications. In the recent years wide-bandgap (WBG) based power converters have been demonstrated to deliver higher efficiency and power density than their silicon counterparts for the switching applications characterised in the 200-1000 V rating. WBG semiconductor materials, including silicon carbide (SiC) and gallium nitride (GaN), have presented multiple advantages over Si. The GaN HEMTs exhibits low on-state resistance, small parasitic device capacitance and high critical electric field and therefore can switch at faster speeds and exhibit lower conduction and switching losses. The switching frequency has been continuously pushed up to several megahertz to reduce the passive components size (low pass filter) and increase power density. On the other hand, the switching loss dominates the total power loss under hard-switching conditions, which limits the ability to further increase frequency. An accurate loss model that can estimate switching loss is highly desirable for predicting maximum junction temperatures and

overall power converter efficiency. Moreover, the high dv/dt and di/dt during switching transient, the voltage and current high-frequency (HF) ringing (can be up to 100 MHz) caused by parasitic inductance, as well as high operating frequency raises the concern of electromagnetic interference (EMI). As an inevitable design consideration, EMI issues must be addressed properly; otherwise, the benefits of WBG power devices will be compromised.

The contribution of the PhD project *Development of an analytical model for GaN HEMTs in high frequency/high voltage applications* is to improve the accuracy of the analytical model of the device to better evaluate the voltage/current waveforms and the power losses. For this purpose two important parameters should be taken into consideration: the parasitic inductors in the circuit and nonlinear capacitors of the device. Especially the nonlinearity of the capacitors dramatically impacts the switching losses. Furthermore, very often, the models don't consider the ringing effect caused by the resonance between the parasitic inductors and capacitors. This phenomenon should also be modeled both to calculate the ringing losses and to use the model for the evaluation of conducted and radiated EMI. The work is being carried out using MATLAB Simulink for the analytical model, OrCAD for the comparison with the behavioral models provided by the manufacturers and finally comparing the results with experimental measures. Part of the work was carried out at the Ferdinand Braun Institut in Berlin. Unfortunately, the research stay was interrupted due to covid-19 pandemic that prevented the carrying out of laboratory activities. The desirable objective was to collaborate with an institute at the forefront of research and development of GaN technology, learning many aspects related to the physical characteristics and of devices both on the market and in development, learning to use test tools and to perform device characterization tests.

Development of an integrated ICT platform for municipal waste management

Aiman Rashid



Aiman Rashid is a PhD candidate in Industrial Engineering at the Department of Electrical and Electronic Engineering with research titled *“Development of an Integrated ICT Platform for Municipal Waste Management”*. He received Bachelor of Science in Mechanical Engineering from Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan in Year-2012 with Senior Design Project titled *“An Automated Umbrella (Motorized, Solar and Rain Sensitive)”*; inspired from Mosque Nabawi at Medina, KSA and Master of Science in Design and Manufacturing Engineering from National University of Sciences and Technology, Pakistan in Year-2016 with a Research Thesis titled *“FEA Validation of NiTiPtPd and NiTiPdCu Shape Memory Alloys at High Temperature”*. During this time, the scholar published 6 research papers in international journals and 1 in national journal as well as attended 5 national conferences and represented papers in 3 conferences.

During PhD, the research activities of the researcher are included as a part of the European Project, titled *“Development of a Model Solid Waste Management Program for the Protection of the Sainiq River Basin in Southern Lebanon”* funded under the call for proposal Complementary Support to the Development of Waste Management Schemes (relaunch) *EuropeAid/155108/DD/ACT/LB*.

In particular, the role of the PhD scholar consists in participation in the development of an ICT platform that will be used to the implementation of a waste management system under effective municipality administration. The research student will implement the platform as a concept of Smart City in the administrative area

encompassing Southern Lebanon villages comprising of total 43 municipalities.

The project covered all aspects of municipal waste lifecycle; starting from collection to recycle / compost. It also included state-of-the-art waste treatment techniques, emerging technologies, and optimization of methods. An important aspect of the project is to research (explore, investigate, and develop) alternative methods that could minimize waste generation altogether. Development and implementation of such methodologies will lead towards eco-friendly environment.

The researcher worked in an organized and cohesive manner with the multi-functional project team that involves different research institutions, unions of municipalities, municipalities, and a private company; all based in Lebanon. In addition to the closely related aspects of industrial engineering, such as the computerized management of complex systems, process optimization and waste treatment technologies, the research student had the opportunity to deal with allied project elements (like developing strategy, aligning operations, adapting organizational culture and societal mindset, evaluating system compatibility, scalability, and sustainability etc.) and gain experience in managing European Funding.

Meanwhile, the researcher attended conferences and training workshops nationally and internationally, one the prominent is Smart City Expo World Congress held in Barcelona, Spain in Year-2019. Further, he has attended a training period at University of Florence, Italy and coordinated mutual research activities at Lebanese University, Lebanon.

Rashid A., *et al.*, RES-Q an Ongoing Project on Municipal Solid Waste Management Program for the Protection of the Sainiq River Basin in Southern Lebanon, *International Conference on Computational Science and Its Applications – 2021 (ICCSA 2021)*; Cagliari, September 13-16, 2021 – Under review

Optimization-based monitoring in Power Systems

Antonio Vincenzo Solinas



Antonio Vincenzo Solinas received the M.S. degree in Electronic Engineering from University of Cagliari, Italy, in 2000. Since then, he worked as an R&D manager on audio and video acquisition, compression, and transmission over IP. He is currently pursuing the PhD in Industrial Engineering with the Electrical and Electronic Measurements Group at the Department of Electrical and Electronic Engineering (DIEE) of the University of Cagliari.

As doctoral student his main interest has been towards application of the optimization formulations to deal with ill-posed linear inverse problems in Power Systems. In particular, he has focused on the optimization formulations involving two terms where one is called misfit or residual, the other is the regularization term, the first one takes into account how well the recovered parameters match measurements, while the regularization term considers the a priori information about the unknown parameters. In the formulations the two terms are evaluated with different and suitable norms, usually norm 1 (ℓ_1), 2 (ℓ_2), ∞ , or the 0-norm (pseudo-norm) are used, and they can be composed choosing one of them as minimization objective function and the other one as a constraint (e.g., least square minimum norm) or they can be combined in an unconstrained penalized formulation as in Tikhonov regularization. This kind of formulations are quite flexible and useful to embody in the problem important information derived from instrumentation specification and a priori information about the domain to investigate. These mathematical tools have been applied to the Harmonic Source Estimation (HSoE) in power networks that, due to the characteristics of the problem (limited number of

measurements, and sparse state vector to recover), can be addressed by using the Compressive Sensing (CS), as minimization. The problem has been faced using, first the minimization with equality constraint, then starting from the theoretical aspects involved in the evaluation of the measurement uncertainties, and the reduction of their impact on HSoE algorithms, a new formulation based on the minimization with quadratic misfit constraint has been proposed in the paper *Compressive Sensing-Based Harmonic Sources Identification in Smart Grids*. In this paper, in order to maximize the performance of the proposed formulation, a whitening matrix allowing the recovery of information on the distributions of the measurement errors, and thus the estimation of the corresponding energy bounds, has been also presented. Then the problem of estimating the line parameters in Phasor Measurement Unit (PMU) based monitoring systems in Transmission Grids has been approached. The accurate knowledge of line parameters is important to optimize the functionality of modern transmission networks, but their knowledge is limited for many reasons as inaccuracy modelling, degradation due to age and, to the weather and so on. The mathematical problem is intrinsically under-determined, but it is possible to acquire measurements in different load conditions, making the problem over determined, and solvable thanks to a priori information about unknowns and a comprehensive definition of the uncertainty model. He is currently working on the penalized optimization formulation of the problem to proper exploit the high reporting rate of PMUs in order to increase the estimation performance of the algorithm.

Pegoraro P.A., *et al.*, Compressive Sensing-Based Harmonic Sources Identification in Smart Grids, *IEEE Transactions on Instrumentation and Measurement* 70: 1-10, Art no. 9000810 (2021)

Robust Optimization of Aeronautical Components

Irene Virdis

Aeronautical Gas Turbines can be considered among the most technological and complex devices: high performances must be pursued to ensure long-term life, low fuel consumption and high safety levels. The nominal value of all the peculiar characteristics (i.e. geometrical features or operational conditions) are different from the real ones, and this can cause a difference between expected and actual performances during experiments or in real life.

The causes for the discrepancies are defined noise factors: their sub-category called aleatoric leads to a random variation of the component shape (manufacturing process, stresses induced by high temperatures and rotational movements of turbine blades), differences between nominal working conditions and real ones; the second source of uncertainty is represented by the epistemic uncertainty originated by lack of knowledge, can be ideally driven to zero with more knowledges, i.e. by doing a large number of experiments or using higher fidelity models.

In modern Gas Turbine design it is important to desensitize global performance (objective functions) of the device with respect to the noise factors (uncertain parameters): this is possible by adopting a Robust Design Optimization strategy (RDO), which includes non-deterministic analysis and takes into account the statistical variations of geometry and operational conditions during the optimization process.

RDO can be divided into three main processes: the first is Uncertainty Quantification (UQ) where all the causes of performance variation from expected values are identified and quantified; the Probability Density Functions of all the uncertain parameters are then calculated. The second phase, Uncertainty Propagation (UP), aims to determine the effect of all the noise factors over the performance. Among the probabilistic strategies, the Polynomial Chaos Expansions (PCE) is

used to approximate the complex system behaviour with a polynomial surrogate model, easier to be handled. From this, a Sensitivity Analysis is carried out to isolate the most influencing parameters (Sobol Indices). The PCE can be constructed efficiently making use of adjoint solvers, which provide the gradient of the objective function with respect to uncertain variables, with a computational cost roughly proportional to the direct solver, making the whole UP significantly cheaper.

The last phase of RDO is Robust Optimization (RO), where the best solution, in terms of geometrical parameters, is found. The probability density functions of the uncertain parameters, as well as the information contained in the sensitivity analysis performed in the UP, can be used to drive the optimizer. The final shape of the optimized component is less sensitive with respect to the noise factors, keeping the performance closer to the target.



PhD programme in Mathematics and Computer Science

Coordinator: Michele Marchesi

Vice-coordinator: Roberto Tonelli

The XXXIV cycle of the Doctorate of Mathematics and Computer Science saw the participation of seven doctoral students in a traditional doctoral course which completed the full three years period. Three of them 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, 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, including: Universitat Politècnica de Catalunya, Barcelona (Spain), King's College London, London (UK), Eurecat - Technology Center of Catalonia, Barcelona (Spain), University of Technology, Sydney (Australia), Brunel University of London, Int. Joint Research Centre (JRC) of Ispira, Kent State University, Gran Sasso Science Institute.

Some doctoral students have carried out support activities for the organization of the first and second edition of the Scientific School on Blockchain and Distributed Ledger Technologies, organized by the Department of Mathematics and Computer Science in collaboration with Sardegna Ricerche and CRS4. The second and third 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. Three 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, including: Lecture Notes in Computer Science, ACM Int. Conference Proceeding Series, IEEE Int. Workshop on Blockchain Oriented Software Engineering, Computation, Journal of Automatica Sinica, Applied Intelligence, PeerJ Computer Science Journal, Blockchain: Research and Applications, EPJ Data Science, Big Data and Cognitive Computing, International Journal of Decision Support System Technology, Electronic Transactions on Numerical Analysis, Complexity, HighTech and Innovation Journal, Applied Numerical Mathematics, IEEE Access, Central and Eastern European Software Engineering Conference, IEEE International Conference on Software Analysis, Evolution and Reengineering (SANER), CEUR Proceedings.

<https://dottorati.unica.it/matematicaeinformatica>

Machine Learning & Deep Learning approaches applied to financial forecasting and robo-trading

Andrea Corriga



My current research focuses on using Artificial Intelligence approaches such as Machine Learning and Deep Learning applied to Financial Forecasting. The goal of my research is to build a market forecasting model that feeds a Robo-Trading system. A Robo-Trading system is a software that performs trading processes (such as open and close positions)

autonomously without the physical presence of a human being.

This research was carried out as part of the research project Almost on Oracle with the company Visioscientiae Srl and the Artificial Intelligence Big Data Laboratory (AIBD).

Since the dawn of the financial market, people have been trying to build tools able to provide insights and information about the stock price variations in the near future, as to increase the possibilities to invest in the right company, future, etc. Nowadays, the research in this area is one of the most active amongst the pattern recognition-related topics, and at the same time, it is one of the most challenging. This is mainly because stock prices are often influenced by factors which are quite hard to predict like political events, the behavior of the other stock markets, and, last but not least, the psychology of the investors. These aspects tend to model the market as an entity which is dynamic, non-linear, non-parametric and chaotic. With the aim to understand and predict the behavior of the market at the daily resolution, we have proposed a novel paper entitled *Deep Learning and Time Series-to-Image Encoding for Financial Forecasting*, which the most important contributions are the use of GAF transformation for encoding time series as images in combination with a multi-resolution timeframe approach. Very briefly, we design our intraday trading strategy, which

consists of buying or selling a specific financial instrument within the same day, using a model build with a Deep Convolutional Neural Network fueled by the GAF images generated using the price market time-series.

As expected by my doctoral program, I was a visiting researcher at the Joint Research Centre (JRC) research group at Ispra. During my collaboration with JRC, I worked on the research project entitled *“Extraction of relevant events with high potential impact on European economies, stock markets, and societies using hierarchical clustering algorithms on European news and social media for economic forecasting and policy analysis”*. Our focus on this project was to use information from news and social network (such as StockTwits) to predict and identify relevant events that will affect the volatility of the Financial Markets.

Barra S., *et al.*, Deep Learning and Time Series-to-Image Encoding for Financial Forecasting, *IEEE/CAA Journal of Automatica Sinica* 7(3): art. no. 9080613 (2020)

Predictive analytics models and tools for decision support of stakeholders in digital agriculture

Francesca Maridina Malloci



Francesca Maridina Malloci is a PhD student in Mathematics and Computer Science, under the supervision of prof. Gianni Fenu. Her research interests span from Predictive Analytics to Decision Support Systems. She earned a BSc and MSc (with honours) in Computer Science at the University of Cagliari. During her PhD, she spent four months at the Data Science and Big Data Analytics research group at Eurecat – Technology Centre of Catalonia (Barcelona, Spain). During her stay at Eurecat, she has broadened her knowledge on decision-making algorithms for multi-stakeholders contexts.

Francesca Maridina's current research focuses on predictive analysis and support tools for achieving sustainable development goals in agriculture. In recent years, the agricultural sector is facing several challenges to counter the effects of climate changes on production. Today's objective is to increase productivity while maintaining high levels of environmental sustainability.

An objective that can be pursued through the development of technologies that favor the targeted and efficient use of natural resources, erroneously considered unlimited and inexhaustible.

The thesis deals with the study, implementation and evaluation of predictive models that perform a dynamic and cross analysis of multidimensional and multisensor data from different distributed sources. The model predictions aim to support field technicians in the prevention and diagnosis of crop diseases. The analysis related to climatic, environmental, and cultural aspects allow to forecast crop risk situation in the short term, and to take prompt actions based on the health of the monitored field.

The scientific contribution is articulated on different levels: from the construction of a dataset to the implementation and validation of models in local conditions, to the development of a prototype Decision Support System LANDS (*Laore Architecture Network Development for Sardinia*) developed for monitoring the main crop production in Sardinia.

Fenu G., Mallocci F.M., Forecasting Plant and Crop Disease: An Explorative Study on Current Algorithms, *Big Data Cogn Comput* 5: 2 (2021)

Software engineering techniques and automatic generation of dApps

Lodovica Marchesi



Lodovica Marchesi earned a MSc in Computer Science at the University of Cagliari in February 2018, with a final grade of 110/110, defending a thesis on the “Initial Coin Offering” (ICO), a new type of crowdfunding for startups, based on cryptocurrencies.

She worked as a research grant on the “Study of Blockchain technology applied to systems for managing complex documents” at the Department of Electrical and Electronic Engineering of the University of Cagliari.

She is currently a third-year PhD student at the Department of Mathematics and Computer Science of the University of Cagliari, under the supervision of Prof. Roberto Tonelli. During her second year she spent five months visiting the Software Engineering Research Group at Brunel University in London under the supervision of Dr. Giuseppe Destefanis, with whom she continues to collaborate.

Her current research fields include the application of blockchain technology in different sectors, cybersecurity for blockchain applications, the study of software engineering practices for blockchain development and distributed applications, and the study of machine learning algorithms and economic and financials models related to the cryptocurrency market.

Blockchain software development is becoming more and more important for any modern software developer and IT startup. Developing dApps can introduce several advantages, for example they are resilient because there is no single point of failure; they are immutable, nobody can change what happens through the application;

assets or personal information may be wholly owned by users. Thanks to their characteristics the opportunities for development are manifold.

Nonetheless, blockchain software production still lacks of a disciplined, organized and mature development process, as demonstrated by the many and (in)famous failures and frauds occurred in recent years. She contributed to develop ABCDE – Agile BlockChain Dapp Engineering, a complete method addressing blockchain software development. The method considers the software integration among the blockchain components -- smart contracts, libraries, data structures -- and the out-of-chain components, such as web or mobile applications, which all together constitute a complete dApp system. The proposed method has also specific activities for security assessment and gas optimization, through systematic use of patterns and checklists. ABCDE focuses on Ethereum blockchain and its Solidity language but preserves generality and with proper modifications might be applied to any blockchain software project.

In the same ecosystem, Lodovica is working to develop a system that, starting from a high-level description of a problem to be solved through a dApp, allows to generate the related blockchain system. Both Smart Contracts and the applications that interact with them via mobile terminals or other devices, will be automatically generated. Also, domain specific languages (DSL) will be studied and implemented.

Marchesi L., *et al.*, ABCDE - Agile Block Chain DApp Engineering, *Blockchain: Research and Applications Journal* 1(1-2): 100002 (2021)

On the computation of the minimal-norm solution

Federica Pes



Federica Pes is a Ph.D. student in Mathematics and Computer Science under the supervision of Prof. Giuseppe Rodriguez. She graduated with honors in Mathematics at the University of Cagliari in 2018. During the three years, she attended several Ph.D. schools and courses both in Italy and abroad. In 2019 she spent a period of two weeks in Copenhagen at Technical University of Denmark and two weeks in Spain at Centro de Ciencias de Benasque Pedro Pascual. In 2020 she spent two weeks at Kent State University under the supervision of Prof. Lothar Reichel. This visit, which should have lasted two months, was interrupted by the Covid-19 emergency and was reverted to remote mode. During her research work, she published a paper in an international journal, she submitted two papers and she gave talks at national and international conferences.

The main theme of her Ph.D. Thesis, *On the computation of the minimal-norm solution of linear and nonlinear problems*, is the study of numerical methods for the computation of the minimal-norm solution of linear inverse problems in the continuous case and nonlinear ones in the discrete case.

Inverse problems are a recent topic in mathematics. Their study is motivated by the technological development of the last decades; for example, some of the more sophisticated medical diagnostic machines solve inverse problems, such as computed tomography. Another application concerns the study of the subsoil in a non-destructive way, through the propagation of electromagnetic or seismic waves. An inverse problem takes the form $Ax = b$, where A is a linear or nonlinear operator, x represents the unknown solution, and b is the information

available, that is, the measurements dataset. The goal is to reconstruct starting from . Inverse problems are closely related to the concept of ill-posed problems. To understand this concept, we need to resort to the definition given by Hadamard at the beginning of the last century: such problems may not have a solution, or may have more than one, or that solution is not stable with respect to perturbation in the data. In applications, ill-posed problems are common whenever there is little available measured data compared to the number of unknowns. In this case, it is necessary to reformulate the original ill-posed problem into a well-posed problem. A typical approach is to resort to a least-squares problem, in which the mean square error between the first and second members of the problem is required to be minimal.

In collaboration with G. Rodriguez, she studied nonlinear problems that may have more than one solution. They propose an iterative method to determine, among the infinite solutions of the problem, the one that has the smallest norm, i.e., the minimal-norm solution. In applications, one frequently encounters ill-conditioned problems, that is, problems in which a small error in the data leads to a large error in the solution. In this case, it is necessary to resort to regularization methods, which transform the ill-conditioned problem into a better conditioned one. Classical approaches to regularization are the application of the truncated singular value decomposition or Tikhonov regularization. In the last year, she focused also on the study of Fredholm integral equations of the first kind. In such equations, the right-hand side is a known function, and the solution is an unknown function under the integral sign, which is sought in particular Hilbert spaces. The solution of integral equations of the first kind requires regularization methods since these problems are ill-posed.

Pes F., Rodriguez G., The minimal-norm Gauss-Newton method and some of its regularized variant, *Electron Trans Numer Anal* 53: 459-480 (2020)

Generalized Adaptive Refinement for Grid-based Hexahedral Meshing

Luca Pitzalis



Luca Pitzalis earned his B.Sc. and M.Sc. in Computer Science at the University of Cagliari, where he also attended his Ph.D. course in Math and Computer Science. His research focuses on Computer Graphics, specifically on Grid-Based Hexahedral Meshing algorithms. Since March 2021 he collaborates with the University of Technology Sydney (UTS) under the supervision

of Prof. Nico Pietroni.

During his Ph.D. he worked on different projects. The most important are Py3Dviewer, a Geometry Processing library for fast prototyping in Python; Optimal Dual Schemes for Adaptive Grid-Based Hexmeshing, a novel approach for installing dual transition schemes in adaptive grids and *Generalized Adaptive Refinement for Grid-based Hexahedral Meshing*.

The latter is the main contribution of his Ph.D. thesis *Advances in grid-based hexahedral meshing*. The goal of this project is to produce adaptive grids that can be turned into pure hexahedral meshes, trying to minimize the total number of hexahedra required to approximate a given input shape. Previous works solve this problem using Octree structures that respect the balancing and pairing constraints. *Generalized Adaptive Refinement for Grid-based Hexahedral Meshing*, instead of solving the pairing algorithmically through an Octree, optimizes a minimization problem. Given an input mesh, the algorithm builds an adaptive grid that is more refined where the input shape presents more details. After one first step of balancing, the grid is decomposed into binary subgrids that enclose only two consecutive levels of refinement. The pairing problem is solved iteratively one subgrid at a time and all the changes are transposed into the global grid. Once all the iterations are done,

the global grid will respect the balancing and the pairing constraints required for generating a pure hex-mesh. This method outperforms previous approaches by a significant margin and guarantees the grid to be at worst the same size as a grid produced by an Octree.

Machine Learning powered financial forecasting for statistical arbitrage

Maria Madalina Stanciu



Before pursuing the Ph.D. program at the University of Cagliari, I received my Master of Science and Bachelor of Science from Military Technical Academy, Bucharest, Romania, with a major in Information and Communication Technology in 2007. Then I worked several years in the computer software industry as a Software Engineer and building highly scalable and distributed systems within the responsible financial investments domain.

As a Ph.D. student, my main focus is to use machine learning algorithms in the financial domain, such as algorithmic trading, in particular, Statistical Arbitrage. On a high level, Statistical Arbitrage implies automatically trading a set of assets by performing both long (buying) and short (selling) operations. The main goal of such a trading strategy is to successfully combine the assets to eliminate, or at least significantly reduce the risk factor, and increase the profit at the same time.

Financial time series have unique characteristics that make prediction tasks challenging, most notably close to random walk behaviour and low signal-to-noise ratio. With this in mind, we have proposed a Statistical Arbitrage trading strategy with two key elements. First, an ensemble of regression algorithms for asset return prediction. Second a dynamic asset selection to reduce the risk. More specifically, we construct an extremely heterogeneous ensemble ensuring model diversity by using state-of-the-art machine learning algorithms, data diversity by using various input features, and method diversity by using a model selection process. Then, the outputs of the ensembles constitute the input of the quality assurance mechanism that prunes assets with poor forecasting performance in the previous periods. The proposed approach proved to yield superior results during both financial tur-

moil and massive market growth periods. Moreover, it has a general application for any risk-balanced trading strategy aiming to exploit different asset classes.

Also, during my Ph.D. studies, I was invited as a collaborator to the Joint Research Centre (JRC) of Ispra, Varese, Italy. The research program was funded by the European Commission Joint Research Centre to the Department of Mathematics and Computer Science of the University of Cagliari. Within this timeframe, I was involved in various technical tasks related to the identification of relevant financial events in Europe leveraging the use of hierarchical clustering of media from news and social media.

Carta S.M., *et al.*, Ensembling and dynamic asset selection for risk-controlled Statistical Arbitrage, *IEEE Access* 9: 29942–29959 (2021)

Financial time series forecasting using traditional econometrics methods and Artificial Intelligence algorithms

Nicola Uras



Nicola Uras holds a master's degree in Theoretical Physics at the University of Cagliari in February 2018, bringing a thesis entitled "Noncommutative Geometry of the Quantum Clock", with a final grade of 110/110L.

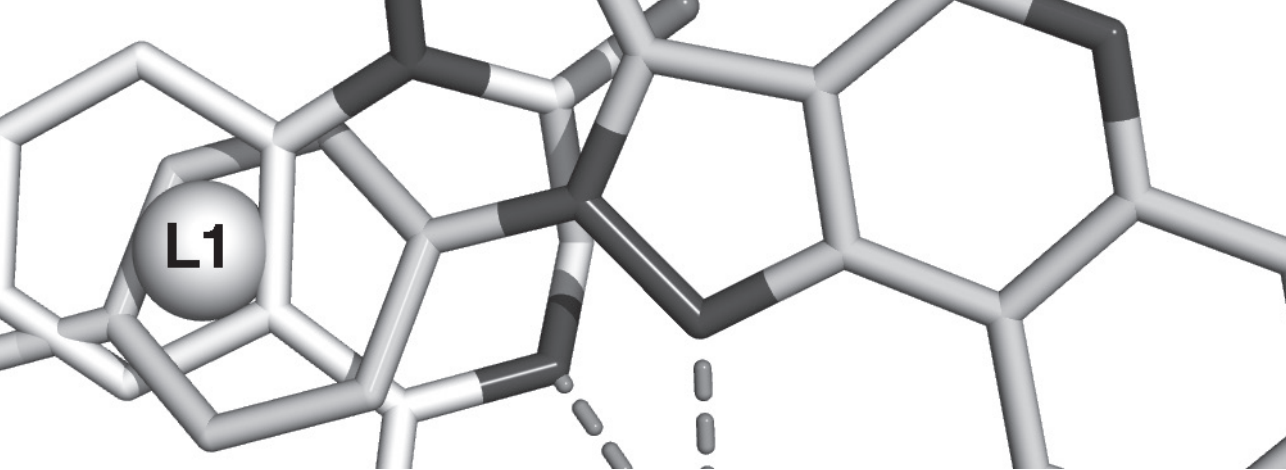
He is currently a third-year PhD student at the Department of Mathematics and Computer Science of the University of Cagliari, supervised by Prof. Michele Marchesi. He has collaborated with Dr. Giuseppe Destefanis of the Brunel University in London with the purpose of applying Natural Language Processing techniques to time series forecasting problems.

His research is based on financial time series forecasting, mainly focusing on Cryptocurrency market including Bitcoin and Ethereum cryptocurrencies. The focus of this research is to analyse and predict cryptocurrency's price series using both traditional econometrics methods and state-of-the-art artificial intelligence algorithms with the purpose of comparing these results with those obtained for traditional stock market time series. This comparison highlights that the analysis of cryptocurrency's price behaviours is a more sophisticated problem. Several are the reasons behind this finding such as the higher volatility in cryptocurrencies prices rather than in fiat currencies and the dynamic nature of the cryptocurrency market due to its recent birth. At the same time, the analysis of a market whose price behaviour is still largely unexplored has a fundamental impact not only in the scientific field but also within economic and financial fields, serving as a source of information for speculators and investors.

In this ecosystem, he and its colleagues enriched the state-of-the-art proposing a novel study to analyse and predict the most valuable cryptocurrencies at the moment, i.e., Bitcoin, Ethereum and Litecoin, comparing these results with those obtained for three traditional stock market price series, namely Microsoft, Intel and National Bankshares. In this work we forecast daily closing price series using data of prior days following different approaches in parallel, implementing both statistical techniques and machine learning algorithms. We proposed a novel approach of identifying stationarity within price series, that is segmenting time series into shorter overlapping sequences in order to find shorter time regimes showing stationarity features so that they can be easily modelled.

Cryptocurrencies arouse keen interest not only in the scientific and financial fields but also within social media communities, making the analysis of their price behaviours one of the most discussed topics of the last few years. Several are also the studies that tried to use online information, including social media topics discussions, to predict cryptocurrencies price changes, proving the existence of possible cause-effect relationships between the cryptocurrency price changes and online information. For these reasons, Nicola is working to apply Natural Language Processing techniques to improve cryptocurrencies prediction using both macroeconomic variables and online information, such as developers' comments and social media discussions.

Uras N., *et al.*, Forecasting Bitcoin closing price series using linear regression and neural networks models, *PeerJ Computer Science Journal* 6: e279 (2020)



PhD programme in Molecular and Translational Medicine

Coordinator: Sebastiano Banni

The Molecular and Translational Medicine graduate 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 Université 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 34th 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.

Angiogenic profile variation in cancer patients receiving anti-angiogenics

Eleonora Lai

Curriculum: Molecular Oncology and Pathology



My interest for clinical and translational research in cancer patients started during the last years of Medical School at UNICA and grown during the Post-graduate School in Medical Oncology. I graduated in Medicine and Surgery at UNICA in 2012 and specialised in Medical Oncology at Sapienza, University of Rome in 2018. I joined the PhD Program in Molecular and Translational Medicine at UNICA in October 2018 and since then I attended the Medical Oncology Unit and Medical Oncology laboratory of University and University Hospital of Cagliari, under the supervision of Prof. Mario Scartozzi.

Since the start of my PhD program, in accordance with my Supervisor, I am actively involved in translational and clinical research, educational and didactic activities, national and international congresses. As the Medical Oncologist Responsible for clinical trials in Medical Oncology at the Medical Oncology Unit of the University Hospital of Cagliari, I am study coordinator and sub-investigator in several phase II, III and observational trials mainly on gastrointestinal tumours and prognostic/predictive factors, in accordance to principles of Good Clinical Practice.

My research activity focuses on the mechanisms of resistance to anti-cancer biologic agents in gastrointestinal tumours, in particular to PARP-inhibitors in pancreatic cancer, to anti-epidermal growth factor receptor (EGFR) monoclonal antibodies in colorectal cancer (CRC) and to anti-angiogenic agents in hepatocellular carcinoma (HCC) and CRC. We presented the results of these studies on international scientific journals and at national and international conferences (AIOM, ESMO, ASCO). Accordingly, my PhD research project focuses on the

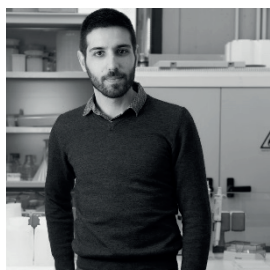
variation of the angiogenic profile in patients with gastrointestinal tumours receiving anti-angiogenic treatment. The aims of my research are the assessment of the angiogenic profile of this patient population during treatment and the identification of prognostic and predictive role of angiogenic biomarkers. Indeed, angiogenesis plays a crucial role in cancer development, growth and metastasis. So, tumour angiogenesis became a crucial therapeutic target for cancer treatment and various drugs targeting the angiogenic pathway are now approved for the treatment of advanced solid tumours, including HCC and CRC. Unfortunately, not all patients respond to anti-angiogenic agents and some of them develop resistance to treatment. Extensive research has focused on potential biomarkers for anti-angiogenic drugs, but to date, no validated predictive factors to identify patients more likely to benefit from anti-angiogenic treatment are available. Possible reasons are the dynamic nature of angiogenesis and the complex interactions among molecular pathways and angiogenic factors. In this perspective, the identification of predictive biomarkers is urgently needed to allow a better selection among cancer patients who are candidates to anti-angiogenics, in order to optimise treatment potentialities, avoid unnecessary toxicities and improve patients' survival. The most promising biomarkers are represented by circulating pro-angiogenic factors. For these reasons, my PhD thesis, entitled "*Pro-angiogenic circulating biomarkers in metastatic colorectal cancer patients treated with anti-angiogenic agent Afibercept in combination with FOLFIRI*" will assess the prospective validation of the vascular endothelial growth factor receptor 2 (VEGFR-2) predictive role in a population of RAS wild type metastatic CRC patients who are prospectively stratified according to VEGFR-2 baseline plasma levels and who receive FOLFIRI-afibercept as second-line treatment after progression on oxaliplatin and an anti-EGFR monoclonal antibody.

Lai E., *et al.*, Are All Anti-Angiogenic Drugs the Same in the Treatment of Second-Line Metastatic Colorectal Cancer? *Front Oncol* 11: 637823 (2021)

Novel biomarker for the diagnosis of neurodegenerative disease

Elias Manca

Curriculum: Molecular Oncology and Pathology



Elias completed his BS in Medical Laboratory Techniques at the University of Cagliari; then he completed his MS in Medical Biotechnologies at the University of Siena. Afterwards he won a scholarship for the PhD program in Molecular and Translational Medicine at the University of Cagliari, with the academic specialization in oncology and molecular pathology. His research

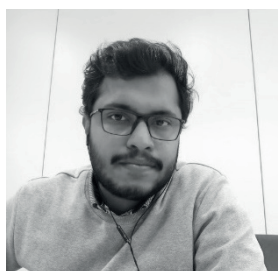
is focused on the identification of new biomarkers for the diagnosis of both autoimmune and neurodegenerative diseases. Biomarkers are a fundamental tool in the medical practice. They can be used both for the diagnosis and follow-up of a disease. In addition, these molecules are also studied to identify which pharmacological treatment is recommended for the patients and how they respond to therapy. Throughout his PhD, Elias worked simultaneously at several projects. His main project is focused on the identification of new autoantibodies among patients affected by Lupus. This project involved the collaboration between the cytomorphology department and the rheumatology department, of the University of Cagliari. Lupus is a complex autoimmune disease that virtually affects any organ of the human body. In other words, it is a disease in which our immune system, the system in charge to protect us from the development of diseases, instead of defending our body it begins to attack it. During normal conditions, when microorganisms or toxic agents enter the human body a specific subgroup of immune cells, called B cells, produce antibodies to eliminate them. Antibodies are specialized molecules able to protect our body by discerning between self- and non-self-component. However, the B cells of patients affected by this disease produce antibodies which are not able to discern between self and non-self. Because of this reason these self-reactive

antibodies are called with the name of “autoantibodies”. During the disease course of Lupus, autoantibodies begin to attack the patient’s organs, thus compromising their function. Eventually autoantibodies lead to a condition known as “organ failure”, afterwards the patient dies. Although there is no cure for this disease, a prompt diagnosis can help to delay the most invalidation symptoms and ameliorate the condition of these patients. At the cytomorphology department Elias dealt with the identification of new antibodies that specifically recognise self-component of the human brain. Whilst at the rheumatology department he studied how the B cells of these patients respond to the pharmacological treatment. At the same time Elias is involved in other projects about a molecule called VGF (non-acronymic). VGF is a neuropeptide involved in many neurodegenerative diseases. He studied this molecule as novel biomarker for the diagnosis of Parkinson’s disease and multiple sclerosis. He participated to the “Contamination-Lab” (a competition held by the University of Cagliari which promotes the birth of innovative startups) carrying a project about a diagnostic kit for the early diagnosis of Parkinson’s disease. Together with his colleagues won an international award granted by the USA embassy. He actively contributed to the study supporting the scientific background behind this innovative kit (Cocco C, Corda G, Lisci C, et al. VGF peptides as novel biomarkers in Parkinson’s disease. *Cell Tissue Res.* 2020; 379(1):93-107). He spent 6 months at the Institute of Neuroimmunology and Multiple Sclerosis, at the Clinical University of Hamburg. Here he studied the role of VGF as biomarker for the early diagnosis of multiple sclerosis and for the prediction of the relapses of this disease. Both Parkinson’s disease and multiple sclerosis are neurodegenerative diseases of the central nervous system. To date, there is no cure available for both diseases, although it is known that in certain cases the pharmacological treatment can delay the neurodegeneration and ameliorate the condition of the patients. The importance to identify neurodegenerative disease at an early stage lies in the fact that patients at this stage may still be responsive to the therapy. Which means that at this stage with the proper therapy it might still be possible to halt, or even reverse, the neurodegeneration.

Thyroid Hormone in Hepatocellular Carcinoma

Rajesh Pal

Curriculum: Molecular Oncology and Pathology



Rajesh Pal is originally from New Delhi, India. He graduated in Biotechnology (M.Sc., 2017) from Amity University (Noida), India. His graduation thesis was focused on understanding the role of a specific class of ribonucleic modifying enzymes in pathogenic bacteria that causes tuberculosis. He joined the Molecular and Translational Medicine Ph.D. program at the University of Cagliari in

2018. He is working in Prof. Amedeo Columbano's lab, where he is supervised by Prof. Dr. Andrea Perra. His thesis is jointly supervised by Dr. Paolo Uva at the Center for Advanced Studies, Research, and Development in Sardinia (CRS4)/ IRCCS Istituto G. Gaslini.

His Ph.D. project mainly focuses on *Understanding the molecular changes in preneoplastic hepatocytes exposed to thyroid hormone(T3)*. His project aims to identify significant molecular pathways and networks involved in the preneoplastic regression upon T3 treatment in animal models. His study will contribute to the present understanding of the early events of Hepatocellular carcinoma (HCC) development, and the design and development of new therapeutic strategies. To understand the underlying disease mechanism and progression, his group at the University of Cagliari mainly makes use of chemically induced animal models of HCC and Next-generation sequencing Technology. Simultaneously, he is also working with the Biomedicine group at CRS4 in developing standardized bioinformatics pipelines for the analysis of various genomic data.

During his Ph.D., he also had an opportunity to work with Prof. Dr. Diego Calvisi at the University of Regensburg, Germany. He was mainly involved in Investigating the role of the amino acid pathway

in bile duct cancer. During his stay, he had gained extensive laboratory experience with human cholangiocarcinoma cells, human liver cancer cells, Gene Silencing / Gene overexpression experiments, Western Blot, and managing multiple projects.

Kowalik M., *et al.*, Thyroid hormone inhibits hepatocellular carcinoma progression via induction of differentiation and metabolic reprogramming, *Journal of Hepatology* 72(6): 1159-1169 (2020)

Gut microbiome analysis in metabolic, neurological, and inflammatory disorders

Vanessa Palmas

Curriculum: Molecular Oncology and Pathology



She earned a bachelor's degree in Experimental Biology and a master's degree in Cellular and Molecular Biology at the University of Cagliari. During the graduate training she started her research activity at the Molecular Virology laboratory of the Department of Environmental and Life Sciences (University of Cagliari), primarily dealing of the characterization, through *in vitro* biochemical assays, of the enzymatic reactions

of mutant viral proteins capable of evading the innate immune response of the host (VP35 of *Ebolavirus*). During master's degree training she also had a research experience at the Institut für Virologie (Universitätsklinikum Ulm, Germany), during which she has dealt with the analysis of the antiviral activity on human cytomegalovirus (HCMV) of compounds deriving from natural extracts.

She specialized in Microbiology and Virology at the University of Sassari in 2018. Since the specialist training, she have focused on the characterization of the human Gut Microbiota (GM) and its metabolic activity in relation to several pathological conditions (inflammatory bowel diseases and Parkinson's disease) at the Microbiology and Virology Unit of the Biomedical Sciences Department (University of Cagliari), directed by Prof. Aldo Manzin, where she currently carries out her research activity.

She joined the PhD program in Molecular and Traslational Medicine at the University of Cagliari in 2018, whose project entitled "*Gut microbiome analysis in metabolic, neurological and inflammatory disorders*" aims to extend the research activity towards the study of intestinal microbial biomarkers associated with other pathological conditions, such as obe-

sity, endometriosis and Bipolar syndrome, and with the state of health (long-lived healthy subjects), whose results were published on international scientific journals or presented at national conferences.

In recent years, scientific research has turned increasing attention to the study of the GM for its implications on human health. Intestinal microorganisms are known to regulate a complex network of physiological functions; in addition to carrying out structural functions, they are involved in various metabolic pathways essential for maintaining homeostasis. Growing scientific evidences show that an altered GM (a condition known as “intestinal dysbiosis”) is associated with an increasing number of diseases, such as inflammatory diseases, but also with metabolic disorders and with autoimmune or neurological diseases. To date, the identification of microbial or metabolic biomarkers, therefore, represents a first and relevant step towards the development of strategies for early diagnosis, monitoring of disease progression and for the therapeutic treatment of the disease.

The experimental approach is based on the use of innovative omic technologies: metabolomics and metagenomics. The first is carried out using Gas Chromatography- Mass Spectrometry (GC-MS) analytical platforms and Nuclear Magnetic Resonance (NMR) analysis; the second is based on the use of Next Generation Sequencing (NGS) techniques. This field of investigation provides a qualitative- quantitative description of the metabolic and microbial taxonomic diversity of a complex biological *target*, allowing the study of the possible role of the human microbiome on health and disease pathogenesis.

Palmas V., *et al.*, Gut microbiota markers associated with obesity and overweight in Italian adults, *Sci Rep* 11(1): 5532 (2021).

Metabolomic alterations and dependencies in colorectal cancer cells

Martina Spada

Curriculum: Nutritional and Metabolic Sciences



I approached the world of research, particularly in the field of Metabolomics, during my last year of master's degree in Pharmaceutical Chemistry and Technologies at the University of Cagliari. Fascinated by this world, I decided to apply for a PhD position at the Molecular and Translational Medicine program under the supervision of Prof. Luigi Atzori.

My research project, centred on colorectal cancer, focuses on the metabolic reprogramming that occurs in cancer cells, identified as one of the main features of cancer (Hanahan D. and Weinberg R. A., *Cell*, 2011), essential to sustain the increased and uncontrolled tumour proliferation. Another important aspect that I have dealt with in my research project concerns the dependences of cancer cells on particular nutrients, especially glutamine, a non-essential amino acid involved in several biosynthetic and energetic processes. My project entitled *"Metabolomic alterations and dependencies in colorectal cancer cells"* aims to selectively target cancer cells by interfering with the metabolic pathways essential for their survival and proliferation, also using dietary compounds with assumed antitumor activity, like Vitamin C. To achieve these objectives, I am studying the metabolomic profile of several colorectal cancer cell lines characterized by different tumour stages and genetic alterations, to identify metabolic profiles associated with tumour cancer cells development, progression, and response to therapy. The methodological approaches include metabolomic analytical techniques such as mass spectrometry and nuclear magnetic resonance spectroscopy and molecular biology experiments such as Real-time PCR and Western blot analysis.

Tronci L., *et al.*, Vitamin C Cytotoxicity and Its Effects in Redox Homeostasis and Energetic Metabolism in Papillary Thyroid Carcinoma Cell Lines, *Antioxidants* 10(5): 809 (2021)



PhD programme in Neuroscience

Coordinator: Paola Fadda

The PhD International program in Neuroscience is settled at UNICA Departments of Biomedical Sciences, Medical Science and Public Health, which actively collaborate with Italian as well as foreign Universities, research centers and private companies/industries. PhD Faculty board includes both basic and clinical researchers from UNICA and foreign Universities within the international PhD agreement. Some faculty board members belong to the CNR Institute of Neuroscience. Because of the discrete skills of PhD faculty board members, the research covers multiple neuroscience topics, including neuroanatomy, neurophysiology, neurobiology, neuropathology, and neurodegenerative mechanisms, neuropsychopharmacology, behavioral neuroscience, diagnostic biomarkers, and the testing of novel compounds active in the CNS.

The Neuroscience PhD program offers a highly qualified scientific education based on practical training within productive and internationally renowned research groups, in order to provide the required skills to work in the scientific research field.

Effects of antiepileptic therapies on neuronal plasticity

Roberta Coa



In 2013 I graduated in Medicine and in 2018 I specialized in Neurology, both at the University of Cagliari. During the internship in Neurology, I developed my interest in Clinical Neurophysiology and gained expertise in the main investigation techniques for central and peripheral nervous system disorders. After obtaining the certification of the Italian Society of Clinical Neurophysiology for Electromyography and Evoked Potentials, I focused on the study of neuronal plasticity and advanced techniques of electroencephalographic signal analysis.

In 2018 I've started my Ph.D. in Neuroscience at the University of Cagliari. I've carried out my research at the Regional Center for the Diagnosis and Treatment of Adult Epilepsy of the University Polyclinic D. Casula, under the supervision of my tutor, Prof. Monica Puligheddu. I also participated in international randomized clinical trials of antiepileptic drugs.

My research aims to investigate the effect of vagal nerve stimulation (VNS) on neuronal plasticity. Currently, although it has been approved for drug-resistant epilepsy and drug-resistant depression since 1997 and 2005, respectively, the mechanism of action of this invasive treatment is not completely known. Previous studies of our group have shown an effect of vagal nerve stimulation on neuronal plasticity in rats and my goal is to verify whether the same occurs in humans.

For this purpose, I have developed the "RELEVANT" protocol which has been submitted to and approved by the ethics committee.

The title of my Ph.D. thesis is "*Effects of vagal nerve stimulation on neuronal plasticity in the treatment of drug-resistant epilepsy*" and investigates neuronal plasticity through two different ways: the study

of functional electroencephalographic neuronal connectivity and the study of BDNF expression. On the one hand, network neuroscience provides a new approach to investigate neuronal connections from a functional rather than structural point of view: I applied this method to 64-channel EEG tracks recorded before and after VNS treatment to study connectivity changes. On the other hand, the Brain-derived neurotrophic factor (BDNF) is a neurotrophin involved in several processes of neuronal plasticity and its function is influenced by the presence of the polymorphism Val66Met: a correlation between the presence of the mutation and the clinical response to VNS can lead to a better selection of patients since it is currently not possible to predict who will respond to therapy.

My future research is aimed at finding other biological markers to predict response to VNS therapy, correlating treatment efficacy on seizures and cognitive function and quality of life, and studying the action of other antiepileptic treatments on neuronal plasticity.

Neurosteroids in Parkinson's disease

Sara Corsi



Sara holds a master's degree in Chemistry and Pharmaceutical Technology. As undergraduate intern, she joined Prof. Paola Fadda's group, where she was involved in a project focused on the study of the endocannabinoid system and the ABA rat model of Anorexia Nervosa. After her graduation she spent a period at VUmc in Jeroen Geurts' group, studying the aetiology of multiple sclerosis. In 2018 she enrolled the

Neuroscience PhD program, under the supervision of Prof. Manolo Carta, focusing her research on the investigation of neurosteroids in Parkinson's Disease (PD). In 2020 she joined Malin Parmar's group at Lund University, as part of her PhD program, working on a newly developed model for PD, and regenerative cell therapy.

Sara's PhD thesis, entitled '*Neurosteroids in Parkinson's Disease*', is focused on the role these endogenous compounds in PD. A growing body of evidence showed that neurosteroids are dysregulated in PD patients along with their synthetic enzymes. Moreover, these endogenous compounds exert a wide range of activities, which make them an intriguing target for symptomatic as well as neuroprotective treatments.

The most troublesome side effect of the symptomatic therapy with L-DOPA is the development of L-DOPA-induced dyskinesia (LID), which consists of abnormal hyperkinetic and choreic movements in response to long-term L-DOPA administration. Foregoing research has shown that LID arises from dysregulated dopamine release and abnormal striatal dopaminergic signaling. As previously demonstrated by our research group, 5 α -reductase inhibitors (e.g. finasteride and dutasteride) are able to modulate dopaminergic signaling and dampen LID, normalizing some of the molecular alterations induced by chronic

L-DOPA treatment in 6-OHDA-lesioned rats. Sara's PhD research aims at shedding light into the mechanism by which neurosteroids reduce LID in parkinsonian rats and identifying the neurosteroid /s responsible for this effect. For this study, our group was awarded a Michael J Fox Foundation grant with the aim to evaluate the antidyskinetic effect of pregnenolone, and clarify its mechanism of action. The results obtained so far, demonstrate that exogenous administration of this neurosteroid exerts therapeutic effect against LID making this neurosteroid a possible therapeutic tool. We are currently investigating the mechanism of action and a possible interplay with BDNF, given its involvement in the development of dyskinesia.

Parallel studies aim at investigating neurosteroids as neuroprotective therapy. For this purpose, we used a recently established rat model of alpha-synuclein overexpression; in fact, toxin-based models do not reproduce the gradual degeneration of the nigro-striatal circuit, limiting the possibility to investigate neuroprotective interventions. By contrast, nigral delivery of an adeno-associated viral vectors carrying the human alpha-synuclein gene reproduces both the intracellular alpha-synuclein rich aggregates and a slow neurodegenerative process, which are cardinal features of the human disease. Using this model, in a first investigation, we found a specific reduction of allopregnanolone at striatal level, while other neurosteroids were unaffected. Current investigation aims at establishing whether exogenous administration can replenish allopregnanolone levels and exert neuroprotective effects in our animals.

Taste and smell physiological mechanisms and their health implications

Mariano Mastinu



I obtained the bachelor's degree in Biology in 2016 and the master's degree in Cellular and Molecular Biology in 2018 at the University of Cagliari. During the master, I participated at the Contamination Lab of the University of Cagliari. My team developed eFlavor, an innovative electromedical device for the objective evaluation of human gustatory sensitivity, which allowed us to be finalists of the edition 2016 and winners of a special award. From October 2018 I enrolled in the PhD programme in Neuroscience at the University of Cagliari under the supervision of Professor Iole Tomassini Barbarossa. Thesis title: *Taste and smell physiological mechanisms and their health implications*. In 2020, I was PhD visiting student at the Food Science Department of Rutgers University (NJ, USA) (6 months).

I joined Professor Tomassini Barbarossa's research group in January 2016. The research activity focused on the identification of the physiological basis of individual taste and smell variability, on the relationships between taste and smell sensitivity, nutritional status, and health, and on modifications of taste perception. Specifically, we obtained a direct, objective and quantitative measure of the peripheral taste function in response to six taste qualities by means of a new technique based on electrophysiological recordings of the bioelectric potentials generated in the taste cells of the human tongue. The measured values were associated with the perceived intensity, number of fungiform papillae, taste genes and sensitivity for the prototypical taste stimulus PROP. We evaluated the gustatory and olfactory performance in patients with Inflammatory Bowel Disease (IBD). Findings showed an impaired olfactory and taste function in

IBD patients, compared to healthy controls, which were related to specific genes. We also studied how bariatric surgery in obese patients affects taste and olfaction. Results showed an overall improvement of taste and olfactory functions that may affect eating behaviour. During my experience at Rutgers University (NJ, USA), under the supervision of Prof. Beverly Tepper, I studied the emotional reactions in response to food aromas in participants who vary in taste sensitivity to PROP.

Melis M., *et al.*, Electrophysiological responses from the human tongue to the six taste qualities and their relationships with PROP taster status, *Nutrients* 12(7): 2017 (2020)

Cerebral white matter status and resting state functional MRI

Michele Porcu



Michele Porcu got the Medical Degree in 2011 and the specialization in Diagnostic Radiology in 2017 at the University of Cagliari. During the specialization training, in 2014 he attended for six months the Emergency Radiology Department at the University Hospital of Turku (Finland), and in 2016 attended six-months training in Neuroradiology at the Rigshospitalet in Copenhagen (Denmark) for educational and research purposes. He worked as Research Fellow at the University of Cagliari in 2018 for the project *“Integrated approach with imaging and biological techniques for the early detection of cardiovascular damage in acute and chronic disease”* at the department of Medical Sciences of the University of Cagliari, under the supervision of Prof. Luca Saba. He is working as Radiologist at the Diagnostic Imaging department of the A.O.U. of Cagliari since 2018, and he is enrolled as PhD student in Neuroscience at the University of Cagliari (XXIV cycle – Academic tutor: Prof. Giovanni Defazio). His main fields of research are neuroimaging and cardiovascular imaging.

The title of the thesis is *“Cerebral white matter status and resting state functional MRI”*. The research is focused on the in vivo analysis of the effects of white matter status on brain activity by exploiting the resting state functional magnetic resonance imaging (rs-fMRI).

It is known that white matter has a crucial role in connecting the different regions of the brain, and the effects of white matter disruption on cerebral circuits in healthy and pathological conditions are an important field of research in neuroscience. The project of research is focused on the analysis of the effects of two of the most studied imaging

markers of white matter integrity: white matter hyperintensities of presumed vascular origin and fractional anisotropy.

Regarding the first marker, the PhD student conducted a cross-sectional study in a population of healthy subjects and demonstrated that the white matter hyperintensities load of the deep white matter strongly influence the volume and the functioning of the hippocampus in the cerebral network. The analysis of the data was conducted exploiting artificial intelligence algorithms for the automatic assessment of the hippocampal volume and the Matlab platform for the analysis of the brain connectivity. This study as published on the scientific journal *Brain Connectivity* in 2020. Other cross-sectional studies have been conducted by the PhD student for evaluating the effects of white matter hyperintensities and fractional anisotropy on global neural activity and brain networking, both in healthy subjects and in pathological conditions such as carotid atherosclerosis.

Together, the results of this research will help to better delineate the role of these important markers of white matter integrity on the general functioning of the brain.

Porcu M., *et al.*, Effects of White Matter Hyperintensities on Brain Connectivity and Hippocampal Volume in Healthy Subjects According to Their Localization, *Brain Connect* 10(8): 436-447 (2020)

Investigation on maternal immune activation rat model of schizophrenia

Michele Santoni



2017 Master's degree in Pharmacy; 2018 Ph.D candidate at the University of Cagliari. Awarded with two Erasmus scholarships: University of Granada (Spain) 12 months; University of Poitiers (France) 6 months, at the Laboratory of Experimental and Clinical Neurosciences under the supervision of Dr. Marcello Solinas.

I started my Ph.D in 2018 at the University of Cagliari under the supervision of Prof. Marco Pistis where I developed my PhD project *"Neurodevelopmental trajectories from prenatal life to adolescence: investigation on maternal immune activation rat model of schizophrenia"*. In our maternal immune activation (MIA) model, in line with epidemiological studies, an infection in pregnancy leads to detrimental effects in the offspring. Moreover, the combination of prenatal, such as maternal infections, and postnatal environmental insults (e.g., adolescent cannabis abuse) increases risks for psychosis, as predicted by the two-hit hypothesis of schizophrenia. We first characterized the inflammatory scenario during pregnancy. In line with previous studies, MIA-treated group showed an increase of inflammatory markers, such as cytokines and chemokines. Afterwards we focus our attention on the endocannabinoid system during the adolescence. We then assessed the response to the main psychoactive compound of cannabis, the Δ^9 -tetrahydrocannabinol (THC). We found that in adolescence, the MIA-treated group displayed a motor-activating effects compared to vehicle-treated group. Furthermore, we described the dopamine cells activity in the ventral tegmental area (VTA) and their response to THC. MIA-treated group showed a lack of response to THC compared to vehicle-treated group. Our results might contribute to unveil neurobiological mechanisms underlying

a dynamic interplay between the development of endocannabinoid system and brain maturation, and this complex relationship might be compromised by MIA in pregnancy.

Coherently with my research project, I was planning to spend six months in Vienna at the laboratory of Professor Gert Lubec (Department of Pharmaceutical Chemistry Faculty of Life Sciences, University of Vienna, Austria), but it has been cancelled due to the Covid-19 health emergency.



PhD programme in Philosophy, Epistemology, Human Sciences

Coordinator: Giuseppe Sergioli

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 points among different research fields and investigate them as potential resources for the advances in the general context of human knowledge.

The program is shifted in three different pilots:

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. program involves seventy Ph.D. students, distributed along all the three different pilots.

The Ph.D. program in Philosophy, Epistemology, Human Sciences has established partnerships with the Universidade de Lisboa and with the Belarusian State Pedagogical University named after Maxim Tank – Research Schools in Pedagogical and Psychological Sciences.

Adam Smith on Human Nature and the Self

Riccardo Bonfiglioli

Curriculum: Philosophy and History of Concepts



During the first year, my work consisted mainly of bibliographic research and individual study of Smith's complete works under the supervision of Professor Angela Taraborrelli. This resulted in the definition of the research theme; the drafting of a critical bibliography; the identification of a methodological orientation; the identification of a title and the preparation of a three-year work plan. During the year, I attended some seminars, some university courses, gave lectures, wrote reviews and attended a Summer school organised by the University of Palermo. The second year of my PhD was devoted to the reconstruction of Smith's concept of human nature and self and to the study of Smith's secondary literature and polemical (and non-polemical) sources: Hume, Rousseau, Locke, Hobbes, Newton and Mandeville. As such I was to spend a period as a visiting student in Glasgow and Boston (cancelled due to Covid) and I was to give a lecture for the International Adam Smith Society in Tokyo. Since September, for three months, I spent a period at the Walras-Pareto Centre in Lausanne, attending various courses and seminars, where I worked on Adam Smith with Prof. Michele Bee. I presented the results of this work in a seminar in May 2020. Since September 2020, I have been in Paris at the Phare Research Centre of the Sorbonne under the supervision of Prof. Laurent Jaffro. The thesis entitled Adam Smith on Human Nature and the Self aims to provide a philosophical interpretation of the relationship between human nature and the self, within the framework of Smith's moral psychology. The first part deals with: an articulated reconstruction of the concept of human nature focusing on the relationship between natural and social dimensions, between impulsive and rational characters, with respect to the process

of formation of the human being as a moral and political subject and to his way of experiencing and knowing; Smith's conceptions of savage and child; the role of natural education, imagination and sympathy in Smith.

In the second part, the focus is on the dimension of the self, meant as the object of moral judgement, and how the relationship of human beings with their emotions, guilt, shame, self-approbation, self-deceit affects the possibility of a society that guarantees happiness and freedom to the individual. Deepening the theme of immediacy allowed me to explore the relationship between the partial and impartial, selfish and benevolent dimensions of the individual, with an emphasis on the virtues of prudence and self-command. In this context, I described the role of the imagination in relation to the concept of immediacy. Sympathetic experience concerns a combination of the imaginative effort to conceive what the other person feels and a dimension of natural, immediate sympathy. Thus, I showed how immediacy concerned any emotional reaction, e.g. gratitude or resentment, not just certain immediate passions such as fear and anger. I then argued that moral pleasure and displeasure are in connection with physical pleasure or pain. This does not imply in Smith that we have a moral sense in the same way as we have physical senses, and the absence of a moral sense does not mean that the impartial judgements underlying the general rules arise from reason. In discussing Hutcheson and Hobbes's critics, starting with the idea that we judge as appropriate what we can sympathise with, I described how the immediacy of sentimental reactions, such as immediate sense and feeling, is a necessary condition, along with reason, for the formation of the general rules of morality in TMS and not a source of partiality.

Artistic metaphors and storytelling in Sardinia

Alice Guerrieri

Curriculum: Logic and Epistemology



Graduated in Art History, she has a Master's degree in 'Management of communication product and services'. In 2019 she obtained a PON-RI PhD Scholarship (Research and Industrial Innovation - XXXIV cycle).

The research project aims to analyze the metaphorical languages relating to art and to evaluate how these can be interpreted in the context of storytelling. Based on a categorization for artistic metaphors, it is intended to propose a new interpretative reading of the artistic heritage of Sardinia and then suggest a transmedia storytelling.

She participated in the national projects: "LITTERA - Literature and Information Technology: extended texts and Augmented Reality" (in partnership with the Department of Education, Psychology, Philosophy of UNICA and F2, a company specialized in advanced systems for the enhancement of cultural heritage); and "Cluster top-down "Pac-Pac"- point-and-click and cultural heritage" (in partnership with the Departments of Education, Psychology, Philosophy and Civil, Environmental and Architecture Engineering of UNICA).

The visual study of the artistic expressiveness of 'insularity' is the starting point of her research project. Images have a social life, they are ways of making worlds (Goodman, 1978) and can produce new perceptions of the world (Mitchell, 1986). However, some images about Sardinia risk shutting the island in a stereotypical interpretation. That is why it is important to analyze the visual communication and the use of metaphorical language in art and to suggest alternative visions in order to orient the observer's gaze towards new perspectives of analysis and discovery. For instance, trying to categorize a various

corpus of Sardinian pictures and creating a transmedia storytelling on social media platforms to promote artistic heritage.

During her visiting doctoral period at the Faculty of Communication, Culture and Society (at IALS, Institute of Argumentation, Linguistics and Semiotics) at University of Lugano (Switzerland), she analyzed the methodologies of categorization of visual metaphors applied to the advertising context (ex. categorization, Charles Forceville; Vismet 1.0, Marianna Bolognesi) for the purpose of elaborate a method of critical analysis of metaphors to narrate Sardinian art.

The pictures collected until now hide the key to know a 'submerged' heritage of archetypal symbolism and myths that flow into the imaginary that typifies the Sardinia. This artistic treasure activates individual and collective memory processes, it produces identities for the communities.

For these reasons it was considered useful to direct the research towards the analysis of those elements that characterize the identity of the Island and redefine themselves in today's communication methods, to foster a more constructive story and distant from the clichés. Indeed, the storytelling of a place structured on the archetypes of long or very long duration must be continuously refunctionalized, adapted to the times and new communication formats.

Guerrieri A., La miniera e il suo immaginario artistico, in: Gola E, Ilardi E, eds. *Immaginari dal sottosuolo. Le aree minerarie all'epoca del web: il caso Sardegna*. Roma: Manifestolibri; 33-70 (2020)

Emotion and deduction

Lucrezia Pelizzon

Curriculum: Logic and Epistemology



I graduated in Philosophical Disciplines from University Ca' Foscari of Venice and I have been working in the management of European research projects for many years.

I joined the doctoral programme in Philosophy, Epistemology and Human Science at the University of Cagliari with a research project centred on Informal Logic. In Cagliari, I participated to different activities, courses, and seminars in a multidisciplinary research environment. During my first year I was involved in the organization of two departmental conferences, during one of which I also had the opportunity to present a talk. I also gave a talk on epistemological questions for a philosophical education in artificial intelligence at the 4th SILFS Conference.

I am improving my knowledge of Informal Logic and of Psychology of Reasoning and I am training my expertise to use experimental methods to empirically verify logical behaviours in everyday reasoning. My research interest is focussed on the inferential processes, especially on the relationship between inferential processes and emotions. I aim at understanding if emotions may have positive effects on deductive reasoning. In my PhD thesis, entitled "Emotion and deduction. Emotional components in inferential behaviour" two variables are considered: 1) the interpretational difficulties that arise when inferential processes are expressed through natural language; 2) the effect on deductive reasoning of a particular kind of emotional variable, normally classified as negative, when it is "pertinent" and "inherent" to a specific task.

My hypothesis is that personally unpleasant propositions can force people to invoke a more stringent evidential standard than usual:

this process would lead them to a deeper analysis of the available information, maximizing the chances that any flaws or limitations of the data will be detected. Thus, if people are motivated to reject a proposition, they find unpalatable, they also try to find the reason for doing so. Instructions and thematic contents of a task may encourage people to consider the implications of the typically neglected rule of Modus Tollens, guiding them toward a successful reasoning strategy.

Experimental tests were carried out, using different versions of the Wason Selection Task (the most famous test for the Psychology of Reasoning), in order to evaluate the results through the rigorous methods of statistical analysis.

Professional development between critical pedagogy's theory and educational practices

Andrea Spano

Curriculum: Philosophy and History of Concepts



Andrea Spano obtained a bachelor's degree in Communication (2015) from the University of Cagliari and the master's degree in Pedagogy (2017) from the same institution. His specialisation is in Learning Diseases (2018) and is currently a PhD student in Philosophy, Epistemology and Cultural History. His research is focused on the main issues of the professional development, especially regarding non-teaching educators, social educators, and

early childhood's educators.

Professional development is currently thought from two different perspectives. The first characterises the in-service training. It refers to Human Resources Management and includes all training practices which are centred on the business objectives and achievements. The second perspective is based on the development of specific professional skills and knowledge. It is centred on the conformation of the pre-service trainees to the standards of a specific professional profile. Through the observation of education practices, as well as the interactions with educators and professionals in the social field, it gave Andrea the idea that 'professionalism' needs to be reflected and practically developed from the following further perspective. Several jobs require a fair balance between professional development and personal development because these issues are closely related. For this reason, Andrea's PhD studies are focused on the interpretation of the professional development as 'Bildung'. His research aims to produce a pedagogical theory of the professional training and, contextually, to design original approaches to assist people in their own lifelong learning.

One of his formative experience was during the international mobility curricular program. In that period Andrea was hosted by Liverpool John Moores University to study using comparative methods the differences between Italian and English education systems.

Spano A., Il Roundabout. Un approccio per l'educazione professionale, *Annali online della Didattica e della Formazione Docente* 11(18): 274-288 (2019)

Mathematics and the Pythagorean apocrypha

Matteo Varoli

Curriculum: Philosophy and History of Concepts



My interests brought me soon to the study of the intriguing, complex history of Pythagoreanism, especially during the Hellenistic and early Imperial Age: since 2018, when I graduated in Classical Philology in Genoa, I focussed my research on the Pythagorean apocryphal literature. In 2019, I had the opportunity to spend some time studying, as part of my PhD course, at the Centre Jean Pépin and at the ENS

in Paris, under the direction of Tiziano Dorandi; I had there the chance to give a talk on physical and astronomical aspects in the treatise of Ps. Timaeus Locrus, and from that talk I've worked out an article which has been accepted for publication in a forthcoming specialized book on the Pythagorean apocrypha.

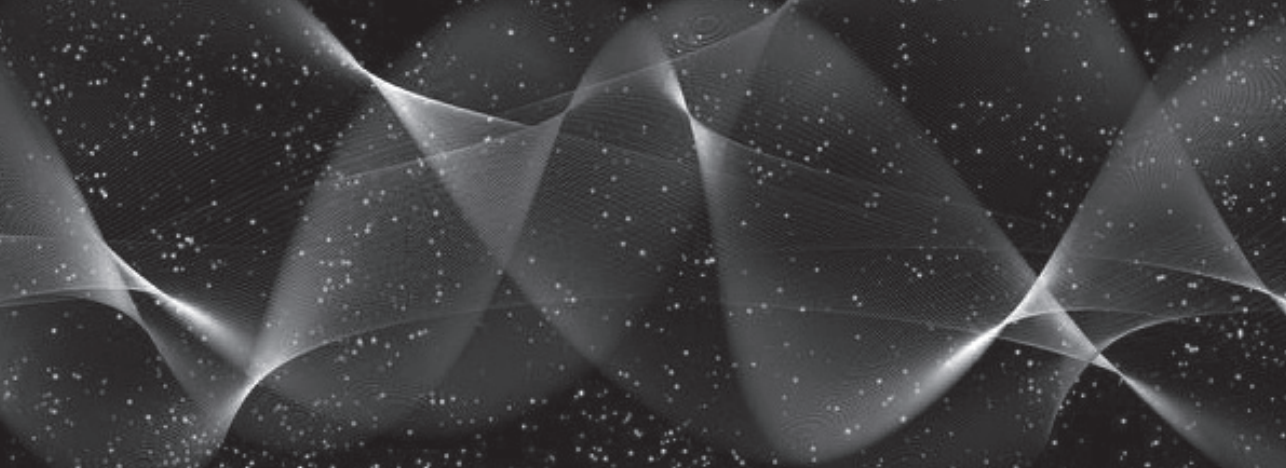
My PhD work, entitled *Le matematiche nella letteratura pseudopitagorica* and carried out under the supervision of Elisabetta Cattanei, investigates a very delicate problem in the history of ancient philosophy and science, the relationship between Pythagorean philosophy and the history of Greek mathematics. The names of Pythagoras and the Pythagoreans are immediately associated with mathematics, especially with geometry and music theory; nevertheless, modern scholars mostly agree that the Master and his first disciples played at best a minor role in the development of what Archytas called the "sister disciplines" which form the core of ancient "scientific" knowledge, namely arithmetic, geometry, music, and astronomy. Between the tragic end of the Pythagorean school and the extinguishing of its last sparkles in the 4th century BC, on one hand, and the full Neopythagorean rebirth of the 1st century CE with figures as Moderatus, Numenius and Nicomachus, on other hand, a long gap of silence lies in the sources on Pythagoreanism; nonetheless, those centuries were decisive for the reshaping of a

Pythagorean identity, and mathematics played in this operation of rebuilding a major role. Most of the testimonies for this long, partly unexplored chapter of the philosophical history of Antiquity consist of Pythagorean apocryphal writings: we know nothing about the real authors of these writings, “forged” in the name of Pythagoras, Archytas, Philolaus and many other minor figures; they adopted mainly Platonist and Aristotelian views as Pythagorean doctrine, and that’s why an investigation on these difficult texts, their aim and their cultural and philosophical context is as hard as fascinating.

The results of this survey are particularly relevant with regard to arithmetic: pseudo-Pythagorean treatises On Numbers seem to have forerun and inspired Neoplatonic and Neopythagorean philosophy of number, and developed at once an arithmetic science, an elaborate theory of knowledge and a theology of number with peculiar features.

My dissertation consists of two parts: the first is devoted to an historical survey, in form of an essay, on the history of Pythagorean mathematics, epistemology and number philosophy in the centuries from the rising of the Hellenistic Age (4th century BC) to the edges of the 2nd century CE. The second part is dedicated to the sources, consisting of a collection of fragments and testimonia related to mathematics in the Pythagorean apocrypha which provides an Italian translation and detailed commentary. The collection is based on Holger Thesleff’s edition, greatly increased, and widely revised with regard both to the selection of texts and textual choices.

M. Varoli, *Il tempo, la Terra, i pianeti. Osservazioni sull’esegesi di Tim. 37c-39e in Ps.-Timeo di Locri*, in: C. Macris, T. Dorandi, L. Brisson (eds.), *Pythagoras Redivivus. Studies on the texts attributed to Pythagoras and the Pythagoreans*, Sankt Augustin, Academia Verlag, forthcoming (2021)



PhD programme in Physics

Coordinator: Paolo Ruggerone

Vice-coordinator: Umberto D'Alesio

The Department of Physics at the University of Cagliari offers the only PhD course in Physics in Sardinia, which assigns a particular role to this course for the Region. A two-fold function is played by the course: it provides a high-level training, and it acts as a further hub for scientific collaborations with the national research institutes (INFN, INAF, CNR). PhD students are strongly involved in large collaborations and experiments as well as in projects funded by international agencies (ERC, IMI, NIH are few examples). The XXXIV Ciclo's fellows have brought their expertise and enthusiasm in research lines related to high-energy physics, theoretical physics, experimental condensed-matter physics, astrophysics, and dark matter studies. To offer a broad educational spectrum, two lines of training should converge. First, PhD students should be exposed to all aspects of research. Active participations to conferences, workshops, summer schools, collaboration meetings and project drafting indicate that our PhD students are well versed in interacting with senior researchers and in fostering collaborations. The quality of their research has been recognized also at international level, considering the strong involvement of PhD students in highly competitive collaborations and experiments, such those carried out at several radiotelescopes (including the Sardinian Radiotelescope) and within the framework of DarkMatter. Second, PhD students should be involved in teaching-related activities. They have been committed to tutoring undergraduate

students at different levels (Laurea Triennale, Laurea Magistrale) and with different backgrounds. Surely, the pandemic emergency with its restrictions have affected the normal route of the PhD course, especially by reducing the face-to-face interactions at all levels and the possibility of spending periods abroad. To reduce these limitations, several instruments have been successfully adopted, such as the possibility to attend lectures and seminars online.

<https://dottorati.unica.it/fisica/>

Highly efficient warm white emission from lead free halide double perovskite

Fang Liu



I graduated at East China University of Science and Technology with master's degree in 2013, my research was focused on the study of air/water interface and oil/water interface for biosurfactant. During this period, I spent two months in the Helmholtz Research Center (Germany) and KFKI Budapest (Hungary) for measurements of Small-Angle X-ray Scattering and Small-Angle Neutron Scattering. From

2013 to 2018, I worked in research and development department of a German ink company SIEGWERK. My job was focused on the investigations on polymers used in ink. In January 2019 I started my PhD in the department of Physics of University of Cagliari and now I work in the Photonics and Optoelectronics Lab under the supervision of Dr. Daniela Marongiu. My PhD research project is focused on the exploratory synthesis of highly efficient lead-free halide double perovskites.

Halide perovskite-based solar cells had achieved 25% power conversion efficiencies within just a few years, which makes them already comparably efficient to silicon-based photovoltaics. However, a critical issue is that these high efficiencies can only be obtained with Pb-based halide perovskites (ABX_3). Among the strategies to overcome the toxicity of lead, the substitution divalent cations Pb^{2+} in single perovskite by a combination of a monovalent and trivalent cation looks promising. This new material forms the so-called double perovskite with a $A_2B^+B^{3+}X_6$ structure. Double perovskites open a new research field on lead-free perovskites. Several different compounds were synthesized in the form of crystal, powder, and film to study the optical properties of double perovskite. In particular, the compound

$\text{Cs}_2\text{AgInCl}_6$, unless it has high absorption properties in the UV region but extremely low absorption in visible region, looks very interesting due to its unexpected photoluminescence (PL) in the visible region. In addition, when Na is alloyed into $\text{Cs}_2\text{AgInCl}_6$, the material shows warm white light emission under UV light. Different alloys were synthesized to improve the PL efficiency with the addition of increasing amount of Bi starting from 0.000001%. The Bi-doped double perovskite appears to be a fantastic single-component warm white light phosphor with photoluminescence quantum yield (PLQY) close to 100%. A systematic synthesis of different compositions was thus carried out by different combination of Bi, Na, Ag and In and the structural and optical properties were studied. All these materials show a high stability in air and they keep the same outstanding emission properties under high humidity thus making them a promising potential material for luminescent solar concentrator or LEDs application.

Liu F., *et al.*, Ag/In lead-free double perovskites, *EcoMat* 2(1): e12017 (2020)

HI survey of the Fornax galaxy cluster

Alessandro Loni



My early studies in physics began at the University of Cagliari, where I obtained my bachelor degree. Then, I moved to Turin, where I completed a master degree in astrophysics and theoretical physics. Finally, since 2019, I have been a PhD student based at the Osservatorio Astronomico of Cagliari. A very friendly environment has welcomed me from the first moment. During these three years,

I have had the occasion to collaborate with several research groups spread all over the world. Before the pandemic began, I also had the opportunity to attend an international radio astronomy work-school in Cape Town and to spend 3 months in Australia working both at the International Centre for Radio Astronomy Research (ICRAR) in Perth and at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Sydney.

My research in Paolo Serra's group aims to shed light on the evolution of the Fornax galaxy cluster as well as of its galaxies. Specifically, we look at the 21 cm spectral line emitted by neutral hydrogen (HI), which tracks the cold gas phase of galaxies. The evolution of galaxies depends strongly on the evolution of their HI content, which is the primary reservoir of fuel for star formation. Furthermore, since HI typically extends to the very outskirts of galaxies, it is the first component that is affected by external forces.

In general, galaxy clusters are the most extreme places of the Universe for galaxies to evolve in. Indeed, they are characterised by a dense intra-cluster gaseous medium, which might cause gas removal in infalling galaxies towards the centre of the cluster. Furthermore, the number density of galaxies within a cluster is higher than in less dense

parts of the Universe; consequently, galaxies are likely to interact with one other through mergers or tidal interactions. Therefore, we expect cluster galaxies to evolve differently with respect to non-cluster galaxies.

Specifically, our target Fornax, is the closest representative of the class of low mass cluster, which allows us to make a further comparison between galaxy evolution in Fornax and that taking place in more massive systems.

In a recent work, we presented the results of an HI survey of the Fornax cluster carried out with the Australia Telescope Compact Array (ATCA). The observations covered the part of the cluster where environmental interactions are more likely to happen. We detected HI from 16 galaxies. Several detected galaxies show disturbed HI morphology and a lower HI content with respect to non-cluster galaxies with similar stellar masses.

Currently, we are observing the Fornax cluster with the most powerful (both in resolution and sensitivity) radio interferometer in the world: the MeerKAT telescope, a precursor of the Square Kilometre Array. Observing twice the same target might be very important, especially if your “eyes” are much more sensitive than before! Imagine being under the sea, open your eyes and try to describe what you see. Now, do it again but wearing a diving mask: how many more spectacular details can you see?

The cycle of MeerKAT observations is just 25% complete and has covered a patch of the sky smaller than that of the ATCA survey. However, these data already reveal long HI tails in four Fornax galaxies and exciting features in other objects never observed before.

My PhD program has received funding from the European Re-search Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (grant agreement no. 679627; project name FORNAX).

Loni A., *et al.*, A blind ATCA HI survey of the Fornax galaxy cluster, *Astronomy & Astrophysics* 648: A31 (2021)

Pixel chamber: a solid-state bubble chamber for imaging of charm and beauty

Alice Mulliri



My PhD work is part of the Pixel Chamber project, which aims to build the first silicon active target based on monolithic active pixel sensors (MAPS) capable to perform continuous, high-resolution ($\sim\mu\text{m}$) 3D tracking of charm and beauty. The detector is conceived as a stack of 216 chips developed for the upgrade of the Inner Tracking System (ITS) of CERN ALICE experiment (ALPIDE), which consist essentially in matrices of 1024×512 monolithic pixels for a total volume of $\sim 30 \times 13 \times 10 \text{ mm}^3$ containing $\sim 10^8$ pixels.

My main task was to develop an algorithm for the reconstruction of proton-silicon interactions inside Pixel Chamber and to test it with Monte Carlo simulations performed using the toolkit Geant4. Simulation consists in sending 400 GeV protons toward the detector to produce proton-silicon interactions inside the sensor.

The algorithm uses a library of five C++ classes suitably developed and has been elaborated to reconstruct hadronic tracks, interaction vertices (primary vertices) and D^0 decay vertices (secondary vertices).

The basic principle of the tracking algorithm is the cluster grouping of hit neighbour pixels considering some limitations on the hits density to avoid merging tracks belonging to the same vertex. Reconstructed clusters are fit with a linear model and fit parameters are used to merge clusters belonging to the same track. The tracking algorithm has an efficiency of $\sim 90\%$ considering a fiducial cut on the primary vertex position to exclude interactions occurring in the last 10 mm of the detector in which hadronic tracks are short and hard to resolve.

The algorithm for the primary vertex reconstruction is based on a method used by several other experiments. The basic principle is to

use a weighted least square minimization of the primary vertex χ^2_{pv} to obtain the vertex position. The procedure is iterative and repeated for every track tested to belong to the vertex.

The resolutions found for the primary vertex position are $\sim 5 \mu\text{m}$ along the beam axis and $\sim 0.5 \mu\text{m}$ along the transversal axes for a track multiplicity of 15. These values are one order of magnitude better than resolutions obtained with some CERN LHC experiments.

The secondary vertex reconstruction algorithm has been developed to reconstruct D^0 decay vertex in the $K\pi$ channel. It is essentially similar to the primary vertex reconstruction, but the fit for the vertex coordinates is done using only two tracks. Preliminary results show that the obtained resolutions are very good and reach $\sim 30 \mu\text{m}$ along the beam axis, $\sim 5 \mu\text{m}$ and $\sim 4 \mu\text{m}$ along the transverse axes.

In the context of the ITS3 project of the ALICE experiment (CERN), the Pixel Chamber algorithm has been used to analyze data acquired during the December 2020 testbeam at DESY. The analysis was performed on bent ALPIDE chips in a particular configuration in which the sensor is parallel to the electrons beam at 5.4 GeV. In this configuration, some electrons scratch the chip surface producing long tracks in the sensor. The analysis shows that the Pixel Chamber algorithm is suitable for this kind of reconstructions too. For this reason, a new setup with a planar ALPIDE chip parallel to the beam has been proposed and accepted for the April 2021 testbeam at DESY. Its aim is to reconstruct even longer tracks and make some measurements such as the production cross section of electrons in silicon.

CP-violation measurements at LHCb

Piera Muzzetto



I started my PhD at the University of Cagliari in October 2018, joining the LHCb experiment research group under the co-supervision of Alessandro Cardini and Francesca Dordei. During the PhD I had the opportunity to attend two schools and to participate in several international conferences, also abroad. In 2020, I won a one-year fellowship to carry on my research at the European Organization for Nuclear Research (CERN) in Geneva, where the LHCb experiment is located, with the possibility to work closely with the experts in my research sector.

My thesis, *Measurements of B meson properties at LHCb*, focused on performing high precision measurements of CP-violating and mixing parameters of B mesons.

The Standard Model (SM) theory of particle physics describes very successfully several experimental observations but fails to explain why the Universe is made almost entirely from matter and not antimatter (the so-called matter-antimatter asymmetry). During the early phases of the Universe life, when the matter-antimatter asymmetry is supposed to be originated, the energy density was high enough to create massive unstable particles. The SM predicts slightly different physical behaviour between matter and antimatter in the interactions and decays of these heavy particles, the so-called Charged-Parity (CP) symmetry violation, that is predicted to be one of the three necessary ingredients to explain the creation of the matter-antimatter asymmetry. Unfortunately, these effects are too small to explain the abundance of matter. This demands the existence of additional sources of CP violation not described by the current theory.

In the present Universe, the massive particles mentioned above are produced only in high energy particle collisions. They can be produced

and studied thanks to high energy colliders, like the Large Hadron Collider (LHC) at CERN. A particular massive particle, the B^0 meson, offers an excellent opportunity to uncover possible CP violation effects not included in the SM, thanks to its abundant production at LHC and the precise SM predictions of several physical observables in this sector. In particular, a specific observable known as the CP-violating phase ϕ_1 , can be computed in the theory with very high precision, therefore the measurement of small deviations from the predicted value can be an evidence of new CP-violation effects.

The main topic of my thesis is the measurement of ϕ_1 , specifically in the decays $B^0 \rightarrow \pi^0 \pi^0$ and $B^0 \rightarrow \pi^0 \pi^+ \pi^-$ using data collected by the LHCb experiment from 2015 to 2018. The ϕ_1 parameter can be measured by studying the decay-time distribution of the B^0 meson. These particular decays were chosen for their clean signature in the detector response and for their relatively high occurrence rate resulting, consequently, in a data set with high statistics and with low background pollution.

Nevertheless, the data analysis is very challenging since the detector and the analysis procedure itself introduce distortions in the decay-time distribution that must be known with high precision and corrected for in the final measurement. In order to cancel most of these distortions, a relative measurement is performed using the very similar control channel $B^0 \rightarrow \pi^+ \pi^-$, whose decay-time distribution is already very well-known experimentally.

Thanks to these studies, a significant improvement in the precision of the ϕ_1 measurements for both decays is expected and it will lead to the best measurements in the world.

Dark matter and neutrino physics at low-energy scale

Emmanuele Picciau



I was born in Cagliari on the 4th of November 1994. I graduated in physics from the University of Cagliari in 2018. The same year, I started my Ph.D. at the University of Cagliari, and the year after I spent 9 months of my research at the University of Massachusetts in Amherst, working in the field of particle physics. Back in Cagliari, I kept researching the same field, in particular studying dark matter and neutrino physics.

Dark matter and neutrinos play a crucial role in the formation and evolution of our Universe. However, most of their features and interactions are still unknown. Thus, increasing our knowledge about their characteristics and their behaviors is necessary to add a piece to the puzzle of our understanding of nature. I started the research about these topics during my bachelor thesis when I first studied the impact of neutrino interactions in the experiments that are trying to detect dark matter particles. During my master thesis, I joined the DarkSide Collaboration by working on data analysis for the search of low-mass dark matter candidates in the DarkSide-50 experiment, a liquid argon time projection chamber located at Laboratori Nazionali del Gran Sasso and running since 2013. Such a background led me to start the Ph.D. at the University of Cagliari with an aimed focus on neutrino properties and the DarkSide-50 detector. To discover the dark matter in experiments such as DarkSide-50, it is fundamental to fully understand the response of the detector used for the search. By analyzing the data taken from 2015 to 2018, an unexpected low-energy effect showed up, limiting the sensitivity of the detector to low-mass dark matter. This effect turned out to be a common feature also for other similar experiments. The just mentioned effect, also called single-electron

background, prevents to have a clean detection at low energies. My contribution provides a more comprehensive investigation of the origin of this effect, showing that a relevant amount of it is linked to photo-ionization phenomena.

To improve the sensitivity of dark matter experiments it is also necessary to predict the components and the effects that may contribute to a “fake” signal in the experiment, so avoiding a misidentification of the dark matter. Among these backgrounds, a particular low-energy process of neutrinos has the chance to mimic very well the signal that dark matter would produce in the detector. This interaction is called Coherent Elastic Neutrino-Nucleus Scattering (CEvNS). The prediction of such a process can be improved by analyzing the data taken by COHERENT Collaboration with detectors made of different targets, such as cesium-iodide and liquid argon. In collaboration with my colleagues in the physics department, I studied the framework involved in the CEvNS process determining several quantities related to neutrino properties, nuclear physics, electroweak interaction, and new physics models which may be the future of the research in particle physics. Besides the broad interest among the community, the studies about the single-electron background and CEvNS in liquid argon would help the DarkSide Collaboration for the development of the next-generation detectors, expected in the next near future.

Cadeddu M., *et al.*, Physics results from the first COHERENT observation of coherent elastic neutrino-nucleus scattering in argon and their combination with cesium-iodide data, *Phys Rev D* 102: 015030 (2020)

Structural and optical characterisation of all-inorganic perovskites

Jessica Satta



Born in Tempio Pausania in 1991, I graduated in Physics at the University of Cagliari in 2018 under the supervision of Professor Pier Carlo Ricci. After the master's, I had a traineeship at Universidad de Castilla – La Mancha, in Ciudad Real, about the characterization of magnetic nanoparticles. In 2018 I started the Ph.D. in Physics at the University of Cagliari, working in the materials science and optical spectroscopy research group (TREETOP) under the supervision of Professor Pier Carlo Ricci. The Ph.D. research project focuses on the *“Structural and optical characterization of all-inorganic perovskites”*. Within this project, in 2019 and 2021, I worked at the BCMaterials (Basque Center for Materials applications and nanostructures, Bilbao – Spain) for a total of 6 months, supervised by the senior researcher Daniel Salazar Jaramillo.

The continued rising demand for energy pushes the research of renewable sources and the development of new systems with reduced consumption. In this view, metal halide perovskites (CsPbX_3 , $\text{X}=\text{Cl, Br, I}$) have garnered great interest due to their intrinsic optical properties and applications, like photovoltaics, phosphors and LED. However, a major issue in the development of caesium lead halide perovskites is the limited time-stability and the understanding of the role of external factors that can induce a crystal phase transformation. Despite the several studies dedicated to increasing their lifetime, the causes of their instability remain unsolved. Several factors affect their stability and properties, like temperature, light flux and/or atmospheric stresses (oxygen, moisture, and heat). In this perspective, reporting the vibrational characterization of CsPbI_3 , we have defined the Raman

spectroscopy as a fast and reliable experimental tool to characterize the different polymorphs of lead halide perovskites, allowing the in-situ study of phase transitions or degradation processes caused by laser irradiation. Further, we developed a solvent-free, solid-state growth method, obtaining samples free of any organic residues and allowing the study of secondary phases and achieving room temperature stable perovskites. From the cost considerations, perovskites could be one of the most cost-competitive materials due to their easy synthesis and cheap raw materials. Considering this, we studied facile strategies to synthesize perovskites encapsulated in a matrix of silica. The synthesized perovskites have long – stability and withstand environmental stresses, like high temperature, presence of oxygen and moisture. Due to the highly efficient luminescence and the high structural stability, they have great potential for LEDs and backlight display applications.

Satta J., *et al.*, Raman spectra and vibrational analysis of CsPbI₃: A fast and reliable technique to identify lead halide perovskite polymorphs, *Journal of Materiomics* 7: 127-135 (2021)

Spin and transverse momentum dependent fragmentation function and their role in hadron production

Marco Zaccheddu



Born in San Gavino Monreale in 1993, I graduated in physics at the University of Cagliari in 2015 with a thesis on “Scattering theory in quantum mechanics” and, in 2018, with a Master thesis on “Spin and transverse momentum dependent fragmentation functions for spin-1/2 hadrons and their role in annihilation processes” both under the supervision of Umberto D’Alesio.

In 2018 I started the PhD in Physics within the hadronic physics theory group (U. D’Alesio and F. Murgia) on a project that focuses on *Spin and transverse momentum dependent fragmentation functions and their role in hadron production*.

The comprehension of the internal structure of nucleons in terms of partons, quarks and gluons, as well as their hadronization mechanism, are fundamental issues in the context of hadronic physics, Quantum Chromodynamics and, more generally, of elementary particles. The parton model uses as key elements, to analyze hadronic collisions, the partonic distribution functions (PDFs), encoding the probability to find a parton with a longitudinal momentum fraction inside a fast-moving hadron, and the fragmentation functions (FFs), giving the probability that a parton fragments into a hadron carrying a certain longitudinal momentum fraction. These two distributions give a one-dimensional picture of the internal structure of the hadrons and are not able to describe many polarization effects, like the azimuthal and transverse single-spin asymmetries observed in inclusive and semi-inclusive processes.

In order to explain these phenomena, it has been introduced a new class of spin and transverse momentum dependent (TMDs) distribution

and fragmentation functions, moving to a 3-D picture of the hadron structure. From the phenomenological point of view, the most studied TMD fragmentation function is the Collins FF, that gives the azimuthal distribution of an unpolarized hadron coming from the fragmentation of a transversely polarized quark. Much less explored is another TMD-FF, the so-called polarizing FF, that gives the azimuthal distribution of transversely polarized hadrons produced in the fragmentation of an unpolarized quark. It was initially employed, almost 20 years ago, in the description of the transverse polarization of Λ hyperons produced in unpolarized proton-proton collisions where some of its interesting feature were tentatively extracted and a good description of data was achieved. The lack of additional experimental information prevented any further theory development.

The new available data, released in 2019 by the Belle Collaboration at KEK, on transverse Λ polarization in processes renewed the interest for this TMD and allowed us to extract, for the first time, the polarizing FF, in a process for which TMD factorization holds. In this work, we have been able to disentangle explicitly the different quark contributions to the Λ polarization, with a good description of experimental data ().

Based on the universality property of this TMD, it was also possible give estimates for the transverse polarization of the Λ hyperon produced in semi-inclusive deep inelastic scattering processes. These results have been collected in the Yellow Report Initiative, that has the purpose to advance the state and detail of the documented physics studies and detector concepts in preparation for the realization of the new Electron-Ion Collider (EIC). Currently I am developing the complete structure of all azimuthal and polarization observables for associated hadron production in annihilation processes, together with the full set of leading-twist TMD fragmentation functions for spin $1/2$ hadrons, both for quarks and gluons.

D'Alesio U., *et al.*, First extraction of the polarizing fragmentation function from Belle data, *Phys Rev D* 102: 054001 (2020)



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:

- *Economics* (economic theory, applied economics, economic geography, tourism economics, behavioral and experimental economics, public economics).
- *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).

- *Quantitative Methods* (mathematical economics, dynamical systems, statistics, machine learning, 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, seven 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*

- Rossella Atzori (*Economics*) in her thesis has developed a series of “Statistical methods for assessing the impact of military presence in Sardinia”;
- Alessio Baldassarre (*Quantitative Methods*) has studied “The analysis of ordinal data through distance-based approaches and matched pairs models”;
- Giacomo Camba (*Quantitative Methods*) presents a thesis where he applies “ML Models to Classify Social Media Sentiment and Predict Stock Trends”;
- Laura Casula (*Quantitative Methods*) has worked on a research titled “Electricity market and renewable energy production”;
- Marta Fundoni (*Business and Management*) focused on the “The future of tourism sector: Environmental Education for tourist children”;
- Parichehr Yarahmadi (*Business and Management*) presents a thesis titled “Luxury goods market: Analysis of the driving forces behind consumers’ purchase intention in the context of Persian Luxury hand-woven carpets”;
- Zammarchi Gianpaolo (*Quantitative Methods*) presents a thesis titled “Eye Tracking and Sentiment Analysis to evaluate user behavior and opinions”.

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

Statistical methods for assessing the impact of military presence in Sardinia

Rossella Atzori

Curriculum: Economics



After concluding a Master's Degree in Environmental Economics at the University of Siena, I received a research grant from the University of Florence for the analysis of consumer preferences in a food-related context. I entered the Ph.D. programme in Economics and Business at the University of Cagliari in 2018.

During the Ph.D. course, I improved my knowledge and skills both through the rich programme of lectures organised by the University and through the involvement in two main research projects. First, I collaborated to the analysis of preferences for water ecosystem services in Sardinia. Secondly, I am collaborating to a project financed by the regional government and involving several departments (PI: Elisabetta Strazzera) aiming to explore the impacts of the military presence in Sardinia with a multidisciplinary approach. Moreover, from October 2019 to February 2020 I visited the University of East Anglia, in Norwich (UK), where I improved my English and benefited from working in an international environment. During the last three years I also had the opportunity to participate to several conferences and to present my work to Italian and European environmental economists.

My research project "*Statistical methods for assessing the impact of military presence in Sardinia*" is part of the afore mentioned regional project and focuses on citizen preferences toward military sites and alternative development prospects. In particular, two case studies have been considered so far: the potential downsizing of the military base of Quirra and the regeneration alternatives for a military site in Cagliari. Besides the empirical aspects, I delved into the methodological aspects of choice modelling, focusing on the modelling of socio-psychological

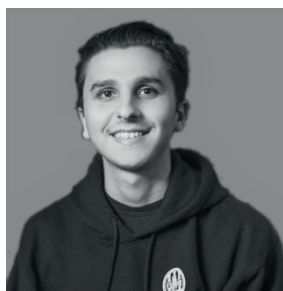
latent variables within the Hybrid Choice Modelling framework. In the last decade this class of models has become increasingly popular as it allows to model at the same time individual preferences through a discrete choice structure and answers to attitudinal questions by the means of structural equation modelling and measurement equations. This offers richer interpretations of individual choices and the possibility to test alternative behavioural hypotheses about the relation between latent factors and choices. However, the latter possibility has been used only to a limited extent in the discrete choice literature. Using the Poligono Interforze del Salto di Quirra as case study, preferences and attitudes toward a potential downsizing of the facility were investigated, with a special attention to the relation between risk perception and benefit perception. Results show evidences of a hierarchical relationship flowing from place attachment, sense of community and trust. In turn, trust influences both the perception of economic benefits and the perception of environmental and health risks, which are negatively correlated. This implies that an individual with a higher perception of risks will tend to underestimate the benefits associated to the facility and vice versa. Also, individuals characterised by different attitudes will attach greater importance to different aspects of the proposed change. A deeper understanding of the underlying factors guiding these decisional processes may guide policies to avoid social tensions and more finely targeted information campaigns. From another perspective, the study of redevelopment and reuse alternatives for a military site in Cagliari (namely Caserma Ederle) offered the opportunity to test further hypotheses concerning individual choice behaviour, as the impact of framing on preference stability and the use of video instructions to improve the decisional process, by promoting institutional learning and reducing choice uncertainty.

Strazzera E., *et al.*, Assessment of renaturation measures for improvements in ecosystem services and flood risk mitigation, *J Environ Manage*, in press (2021)

The analysis of ordinal data through distance-based approaches and matched pairs models

Alessio Baldassarre

Curriculum: Quantitative Methods



I am a 25 years old Ph.D. candidate in Economics and Business. I was born in Napoli, where I graduated cum laude in Economics (statistical path) at the Università Federico II di Napoli with a thesis in computational statistics. I have been hired by the Italian Ministry of Economy and Finance as a statistician officer at the Department of Finances (local taxation office) in 2020. I use to work with a large amount of

data related to local municipalities' revenues and expenses. During my Ph.D. course, I spent 4 months at the Universiteit Leiden as Ph.D. visiting student. The research period in the Netherlands had a strong impact on my professional and personal growth. Furthermore, I had the pleasure of being a tutor in microeconomics at the Università degli Studi di Cagliari.

My research field is centred on the analysis of ordinal data, which can be identified in preference rankings or with any other sortable size data. My first two Ph.D. years were characterized by the analysis of preference data through distance-based approaches. Given a set of M judges, preference data can be expressed through rankings of N items associated with each judge (e.g., the first judge expresses the preference for the items $A, \dots, D = A > C > B > D$). This kind of data is frequent in several scientific fields, and typically the main goal is finding the "consensus ranking", which is the best compromise between a set of stated preferences. For example, in political elections, the "consensus ranking" corresponds to the final election result. When there are only two dimensions (i.e., M judges and N items), the analysis might focus on defining the appropriate descriptive distance-based statistics. My first research period was characterized by the development of a new

weighted correlation coefficient. This index can be used as a measure to be maximized for finding the consensus ranking by applying different weights to the ordered items. The results were presented at the Classification and Data Analysis Group conference in 2019.

In some cases, it may be reasonable to expect that the preferences expressed by individuals depend on their characteristics. Therefore, if a third dimension X is added, we can capture the probabilistic link between individual characteristics and preferences. Following this line, especially during the research period at the Universiteit Leiden, I worked on the development of a new probabilistic model for the analysis of ordinal data. This model is based on machine learning techniques, which combine regression tree algorithms and models for matched pairs. The general framework of this approach was presented at the Statistical Italian Society conference in 2020 and, following developments, it is the main topic of a scientific paper under review. It was developed with the help of my supervisor Claudio Conversano, and the professors Antonio D'Ambrosio, Elise Dusseldorp, and Mark de Rooij. The model predicts the probability of preferring a certain item given the judge's characteristics, and the result is a small regression tree that finds the best interactions between X variables for predicting the mentioned probability. This approach can be used for any kind of sortable data in which there are three dimensions (M individuals, N items, X individual's characteristics). My most recent research products apply this model to economic and fiscal data from OCSE, WB, and IMF databases. Now, the observations are represented by countries, the objects by different levels of taxation (property tax, payroll tax, tax on goods, etc...), and the individual's characteristics by the main variables of national accounts (e.g., GDP growth, investments, public spending, etc...). This type of application can be helpful for decision-makers to investigate the relationship between tax revenues' composition and the economic framework, by partitioning countries according to their tax systems, and estimating the probability that a certain level of taxation is higher than another.

ML Models to Classify Social Media Sentiment and Predict Stock Trends

Giacomo Camba

Curriculum: Quantitative Methods



My name is Giacomo Camba and I live in Cagliari. My university career does not start immediately after high school but after a work experience as an insurance consultant in which I have gained strong skills in the analysis and management of risks of public and private companies. After five years of intense work, I decided to go to university well aware of the choice I was making. I obtained a bachelor's degree in Economics and

Business Management and immediately after that a master's degree in Financial Markets. The idea of continuing my academic career with a doctorate arose during the development of my master's thesis. In 2019 I presented a work, cut out of my master's thesis, at the 12th Meeting of the "Classification and Data Analysis Group (Cladag)", and thanks to this I also obtained a publication.

Regarding my path as a Ph.D. student, after the first year invested in following the canonical courses offered by the *SEA Quantitative Methods* doctorate study program, I was finally able to fully concentrate on my research interests, concerning the statistical analysis of financial markets, the investment and trading field, the risk management, macroeconomics and machine learning. My research project was born with the intention of combining all these aspects.

In the first part of my project, I deal with social media sentiment with the aim of building sentiment variables to be used later as predictors of machine learning models together with other economic-financial variables. The data was collected mainly by Stocktwits and Twitter. On the former I trained and tested various classification models in a supervised learning environment and on the latter, I went to use the best performing classifier to tag Twitter tweets that are unlabeled.

The most relevant aspects in this session concern the extraction of the features and the models I used. Regarding the extraction of the features, the methods I used are Tf, Tf-idf, Word2Vec (CBOW and Skip Gram), Doc2Vec (DBOW, DMC, DMM, and concatenations of these), in the declinations unigram, bigram, and trigram. Regarding the models I used, they are mainly the ANN, CNN, LSTM and pre-trained BERT transformer.

In the second part of my work I built some forecast models of stock trends using the sentiment and interest variables obtained in the first section of the work together with macroeconomic variables as predictors. The data collected mainly concern: monetary policy variables (policy rates and monetary aggregates), bond market variables (bond rate curves), inflation variables (CRB index and CPI index), labor market variables (unemployment rate, Non-Farm-Payrolls and average hourly wages), and other stock market sentiment variables. The goal in this section is to build machine learning models that provide a predictive performance of more than 50%. Specifically, the Random Forest, SVM and ANN models are implemented.

In the third and final part, the information obtained from the previous section will be combined with the statistical analysis of the American stock market to build a trading system.

Electricity market and renewable energy production

Laura Casula

Curriculum: Quantitative Methods



After graduating in Statistics at University of Bologna, I have improved my knowledge and skills working thanks to the achievement of two second level masters in the field of medical statistics and a 15 years experience in the research field. This was accompanied by constant commitment as a university teacher for courses in both mathematics and statistics at

various departments of the University of Cagliari.

With the start of my experience in the doctoral school, thanks to the passion and support of my tutor and his research group, I was able to discover the almost completely unknown “world” of stochastic processes.

The leitmotif of my research work is the theme of electricity, with a particular focus on the increasingly current theme of renewable energy, whose expansion is destined to increase in the future, under the impulse, for example, of the Paris agreements, with the aim of reducing the production of greenhouse gases.

My research begins by addressing the problem of the volatility of electricity prices as a consequence of the liberalization of electricity markets and the introduction of renewable energy using different regression techniques to determine suitable explanatory variables regarding the possible connections between futures and spot prices and to consequently deduce information on the ex-post risk premium and the net convenience yield.

The attention then shifted to the analysis of a specific form of renewable energy, that of wind power. The study conducted led to estimate the income generated by a wind turbine over a given time

interval using a vector autoregressive process (VAR) that consider the dependence between wind speed and electricity price.

The natural continuation of the research project led to the study of another renewable energy, shifting our attention to the production of energy through photovoltaic (PV) panels. The efficiency and quantity of energy produced by a PV panel depend on both deterministic and stochastic factors; through the modelling of the latter is possible to estimate the energy production of a PV system with fixed technical characteristics. Besides, it is possible to determine the economic profitability of the plant using the hourly spot price curve of electricity and its correlation with solar radiation, via vector autoregressive models.

The last part of the research project aims to analyze the electricity generation of a mixed wind-photovoltaic system considering a multivariate model that involves not only the required climatic variables but also the price of electricity in order to evaluate the profitability of the system through the expected income.

The future of tourism sector: Environmental education for tourist children

Marta Fundoni

Curriculum: Business and Management



Marta Fundoni is a Ph.D. Student at the Department of Economics and Business at Cagliari University. Fundoni graduated from Urbino University (Italy) with a Master's degree in Business Marketing and Communication. She has previous experiences as Erasmus student at Valladolid University (Spain) and as visiting Ph.D. student at Granada University (Spain). Her

research focus includes tourism marketing, environmental education, and sustainable tourism, focusing on families and children as tourists.

Nowadays, sustainability is a relevant topic all over the world. Both countries and governments agree on considering planet earth's conservation and preservation as an urgent issue to manage, developing the Sustainable Development Goals, a comprehensive guide with specific objectives to reach within 2030. Tourism and education are both cited as prominent points in the Agenda 2030. On the one hand, it is necessary to promote sustainable tourism practices. On the other hand, access to education has to be guaranteed. For these reasons, Environmental Education begins to be considered more and more in pursuing these objectives.

My research project, *The future of the tourism sector: Environmental Education for tourist children*, focuses on these fundamental issues. The aim is to identify opportunities and weaknesses for tourism organizations in pursuing these goals through EE's marketing and management actions, especially considering tourist children and their families.

During the initial part of my project, I could extend my knowledge about these topics, especially exploring the multidisciplinary context using systematic methodologies to conduct literature reviews.

I also conducted a series of qualitative interviews with CEAS (Environmental Education and Sustainability Centres of Sardinia) as a case study. Analysing CEAS' work, I provide the most effective ways for the tourism sector to educate tourists children and their families, giving some managerial implications and indications helpful for all the tourism organizations. Through few marketing and management actions, tourism organizations could raise awareness, protecting and promoting tourism destinations. The tourism sector can educate the adult tourist of today and the tourist children, namely tomorrow's tourists, simultaneously. The cooperation between tourism organizations and CEAS could create a new conscious generation of travellers. Moreover, I provide suggestions on a possible regional policy path that includes renovating the image of Sardinia as a 'sustainable island', both protecting the tourism destination and promoting the local food and culture, according to the SDGs.

This research project provides a bridge between Environmental Education, tourism marketing and management, and sustainable tourism. The study is quite indisputable of current relevance by giving a clear and helpful path over the short and long terms.

Luxury goods market: Analysis of the driving forces behind consumers' purchase intention in the context of Persian Luxury hand-woven carpets

Parichehr Yarahmadi Dehnavi

Curriculum: Business management



After receiving a bachelor's degree in business management in 2012, being qualified as the first student ranked among sixty bachelor students of Business management. Then, spending my Master academic years in the field of Executive Master of Business Administration (EMBA), and finally graduated from Shahid Bahonar University, Kerman, Iran in 2014. From October 2018, I have been accepted as a PhD student at department of Business and Economics, University of Cagliari, Italy. My research field is luxury marketing and consumer behaviour under supervision of Prof. Giuseppe Melis at this department and co-supervision of Prof. Saeedeh Rezaiee at PSB (Paris School of Business), France.

During my PhD academic years, I have had the opportunity to learn how academic research works, acquiring new concepts, through classes, exams and analysing multifarious papers through the courses, all of which I had not face with previously.

Growing more specialized in the field of Luxury marketing and consumer behaviour is one of the advantages of deciding to accomplish my PhD thesis on: *"Luxury Goods Market: Analysis of the driving forces behind Consumers' purchase intention in the context of Persian hand-woven Carpet Market"*. Investigating the main factors influencing the process of decision making in Iranian hand-woven carpet market is the focus of this study.

To clarify more, the issue of luxury brand consumption has burgeoned amongst branding practitioners and academics during recent years and consumers engaging in the consumption of luxury brands are bringing about unique positions and identities. However, little is known regarding how to optimize the market and balance consumers' preferences in this particular consumption context. So, this research took some steps towards exploring the position of luxury hand woven carpet market in the Iranian consumers' mind through examining some specific marketing constructs such as brand image dimensions, perceived quality, status consumption, conspicuous consumption, willingness to pay.

At the same time, investigate the effective factors for enhancing the position of this luxury good. More interestingly, studying consumers' motivation behind their luxury purchase in this specific market is one of the other phases of this research. In fact, according to the features of Iranian hand-woven carpets, three kinds of motivations amongst five (veblenian, snob, bandwagon, hedonist, perfectionist) were matched and investigated. Discovering how Iranian luxurious hand-woven carpet can find its place among other brands around the world along with providing conceptual frameworks can be implemented for different countries and various industries, are of the other phases of this research.

The applied methodology for this study is defined through the following steps: Firstly, designing the research questionnaire, pretesting and revising it. Secondly, distributed the finalized questionnaire among Iranian consumers of luxury hand-woven carpets. And finally, assessing the collected quantitative data through applying the SPSS software and Structural Equation Modeling (SEM) through using AMOS 26 software so as to clarify the relationship among variables.

Eye tracking and sentiment analysis to evaluate user behavior and opinions

Gianpaolo Zammarchi

Curriculum: Quantitative Methods



My name is Gianpaolo Zammarchi and I'm a PhD student in Economics and Business Sciences at the University of Cagliari. In 2016, I completed the Business and Economics Bachelor's degree program and in 2018 I obtained a Master degree in Managerial Economics, both at the University of Cagliari. During my studies I took part to a research project aimed at describing and analyzing data regarding all traditional (radio, television, and newspapers) and modern media (online newspapers and social networks) currently active in Sardinia. To this aim, I created a survey to collect data of interest from media broadcasters and I conducted the statistical analyses of the data. During my PhD I was tutor of Statistics and Statistical Learning for graduate and undergraduate courses.

One of my main research interests is to apply a versatile and innovative tool such as eye tracking to different types of projects for which it is important to understand which elements of a picture, website, text, etc. attract the attention of a participant, even when the participant is not perfectly aware about it. My research interests also include software development, machine learning techniques and sentiment analysis.

In the first part of my thesis *Eye Tracking and Sentiment Analysis to evaluate user behavior and opinions* I analyze the viewing behavior of high school and university students browsing the UniCa website. Students were asked to find specific information (e.g. libraries, sport center) only browsing the website (no search engines or internal search allowed). Using an eye-tracker, a device that measures the exact eye location, we've been able to assess which part attracted their attention

the most and how much time they needed to carry out the task. In our paper (Zammarchi G., Frigau L., Mola F, 2021) I've used Markov Chain, a stochastic model where the probability of each event depends only on the previous event, to assess how the two groups of students switched from one element to another, showing similar behavior between two groups. Our results suggest that the UniCa portal offers a good web usability also to users with a limited previous knowledge of the website.

In the second part of my thesis I investigated changes in country reputation towards Italy before and after the Covid-19 spread using sentiment analysis on data collected from Twitter and explored whether these changes can be used as early detection signals of stock market performance. We used both machine learning and lexicon-based approaches to analyze the sentiment trend. The latter approach makes use of different dictionaries in which each word is associated with a positive or negative score. Different functions can then be applied to compute the overall sentiment.

Finally, in the last part of my thesis, in collaboration with professor Jaromir Antoch from Charles University (Prague), I developed a new way to evaluate the sentiment of written text using data from an eye-tracking experiment to build a new dictionary. I also carried out some side-projects like, for example, the development of an Android app called "PharmacoloGenius" that offers resources to students, health care professionals, and researchers working/studying in the field of pharmacology. The app also keeps users informed with the latest news and entertained with games that allow students to memorize concepts relevant to different pharmacological topics in a fun and engaging way.

Zammarchi G., *et al.*, Markov chain to analyze web usability of a university website using eye tracking data, *Statistical Analysis and Data Mining*, in press (2021)



PhD programme in Legal Sciences

Coordinator: Gianmario Demuro

Vice-coordinator: Silvia Corso

During the 34 cycle and the academic year 2020-2021, the Doctorate in Legal Sciences focused its teaching and training activities, which were carried out entirely online, on the theme of the relationship between Science and Law, in view of the need to question new phenomena which, like the current pandemic, require close interaction between the two orders of knowledge and a reflection on their mutual tasks and responsibilities.

In particular, all the doctoral students tackled a common research topic concerning the legal problems posed by the health emergency, with the aim of identifying the most appropriate solutions for a policy to combat the pandemic that is both effective and respectful of individual freedoms.

The doctoral students enrolled in the 34th cycle applied to present the initial results of their research at the European Researchers' Night, to be held in September 2021, with the aim of encouraging reflection on the need to combine the protection of public health with individual self-determination in the choice of treatment, also in relation to the possible introduction of a mass vaccination requirement.

Although they were not able to carry out their full research period abroad, the 34th cycle doctoral students carried out remote research activities in 'smart working' at qualified foreign universities, enabling them to complete their research work with a view to writing their final dissertation.

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

Conscientious objection and right to abortion

Stefania Flore



Graduated in 2013 with 110/110 cum laude, I focused my studies on the right of persons (family law, inheritance law). In 2015 I obtained a diploma of specialization for the legal professions and two years later I've been admitted to the Bar of Cagliari. I started my experience as PhD candidate in 2018, with the aim of deepening the relationship between conscientious objection and abortion, problem that had already emerged from my thesis work.

In my studies, both of degree and PhD, I have always considered essential to integrate the study of Italian law with the comparison of foreign law: in 2011 I studied in Paris for six months with the Erasmus program and, as PhD student, I studied two months in Valencia and four months in Brussels.

I am the author of various publications on the topic of family law, one of which is in a class A magazine.

My PhD thesis work, entitled *Conscientious Objection and right to abortion*, is divided into five parts.

The first part concerns the study of the ethical aspects of abortion: why was and is it so difficult to regulate the right to abortion? I will analyse the various theories, including the religious ones, on the beginning of life and the morality of the termination of pregnancy.

The second part concerns the historical profile of the legislation on abortion: through the study of old texts and, as regards the ancient part, thanks mainly to the work of Nardi (Nardi E. *Procured abortion in the Greek world Roman*. Milan: Giuffrè; 1971), I try to reconstruct the history of the legislation on abortion in the Italian regions from Roman times to the present day.

In the third part I deepen the various aspects of the rights involved in the law on abortion: the right to procreative self-determination of women, the right to health, the right of the doctor to conscientious objection, the rights (or rather, the constitutionally protected interests) of the foetus. The research has been carried out with constant reference to multilevel protection, especially to the jurisprudence of the ECHR.

In the fourth part I analyse the current legislation in Italy on voluntary termination of pregnancy (l. 194/1978), highlighting the limits and problems of conscientious objection to abortion. It emerges in particular that the absence of any counterpart and control over the exercise of the objection encourage the presence of “objectors of convenience”, that is when doctors are not moved by their conscience, but by reasons of objective convenience. Abortion is in fact a risky intervention, a possible cause of medical responsibility, that the professional chooses to carry out, actually, without any economic/working advantage. The mobility of staff, although provided for by Law 194/78, is concretely ineffective for the small number of non-objecting staff. The result is an unacceptable violation of women’s rights, which has already been the reason of two convictions of Italy by the European Committee on Social Rights.

The last part then deals with finding a solution to these critical issues, with the aim of outlining a proposal to amend the law, almost a call to the legislator. Searching for this solution, it is fundamental the comparative approach (especially with Spain and Belgium laws), from which it emerges that the institution of abortion clinics allows the recruitment of non-objector personnel, guaranteeing the service.

The right to therapeutic self-determination in the end of life choices

Alessandra Leuzzi



Alessandra Leuzzi was born in Cagliari in 1992. She obtained the Master's Degree in Law from the University of Cagliari in 2017 defending her dissertation on succession law. In the same year, she obtained the *cultrice di materia's* title in private law. She is currently a PHD student in Legal Science (XXXIV cycle) at the University of Cagliari, supervised by Prof. Cristiano Cicero. Her research focuses on the *Right to therapeutic*

self-determination in the end of life.

During the academic year 2019-2020, she spent two months as a Visiting Postgraduate Researcher at the University of Amsterdam (Amsterdam Centre for Transformative Private Law), supervised by Prof. Chantal Mak and her research focused on the Living will and the right to die in a comparative perspective. As a matter of fact, during her research stay abroad, she had the opportunity to deepen how the living will matter is regulated in Netherlands and she had also the possibility to compare it with the Italian national law because, unlike Italy, the Netherlands legalizes euthanasia.

Alessandra's thesis begins with the study of the ethical and legal debate which has concerned doctrine and jurisprudence since immemorial time, and from which is inferred the difficulty to regulate the subject of the end of life in Italy.

The research paper continues by analyzing the most emblematic law cases (such as the judicial case of Eluana Englaro, Piergiorgio Welby and Dj Fabo) which have certainly given a strong impetus to the legislator in order to intervene to fill the regulatory gap. In 2017, the legislator, in light of these important legal cases and requests has finally enacted the legislation number 219 to fill the regulatory gap that characterized the matter of the end of life for a very long time.

The recent legislation has opted for the complete self-determination of the human subject and has finally regulated (for the first time ever in Italy) the informed consent to medical treatments and the advanced directives for health care. By contrast, the legislation does not regulate voluntary actions intended to interrupt life, such as assisted suicide and active euthanasia. Nevertheless, the recent legislation is marked by inconsistencies and timidity and due to this it is the bearer of doubts and uncertainties. For this reason, the purpose of the thesis is to analyse—from a civil law point of view—the interpretative problems that can be raised by the reading of the legislation's text.

The last part of the research paper aims to answer to the ultimate question: is there in the Italian legal system “a right to die with dignity” which justifies, under certain conditions, active medical euthanasia and assisted in suicide? In this respect, the Italian legal system does not provide any legal framework on the subject and, as a consequence, those who help others to end their life are considered and treated as criminals (article 579 and 580 of the Penal Code). Nevertheless, the Court of Assize of Milan has recently raised the question about the constitutional legitimacy of the article 580 c.p in front of the Constitutional Court. The Constitutional Court -on 25 September 2019- ruled that is not punishable, under article 580 of the Penal Code, someone who facilitates the execution of the purpose of suicide, independently formed, of a patient kept alive by life-sustaining treatments and suffering from an irreversible illness, who is however still capable to make conscious decisions.

In essence, under certain conditions, the crime of assisting in suicide has been decriminalized. In my opinion it is appropriate that the legislator intervenes to legalize the murder of the consenting person and assistance in suicide, even though stricter limits on the discipline need to be imposed.

The difficult interaction between political power and globalized economic power

Lorenzo Moroni

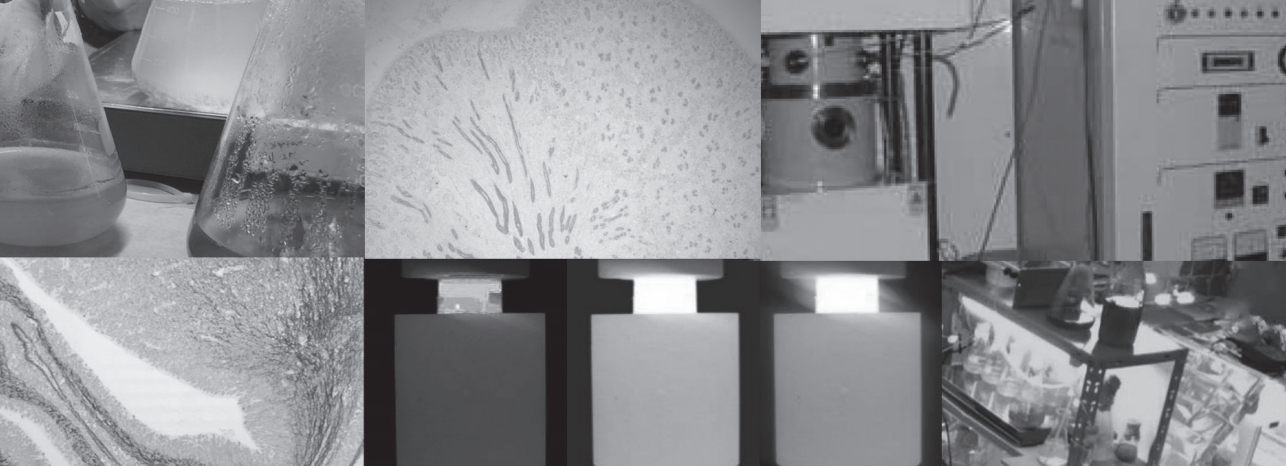


In 2016, I graduated in Law, *summa cum laude*, from the University of Cagliari, where I was declared the second best graduate of the Department of Law for the a.y. 2015-2016. For the writing of my dissertation in Constitutional Law, entitled “The principle of loyal cooperation in the World Trade Organization”, I did a research period abroad at the John Marshall Law School in Chicago. After graduation, I was appointed as a *cultore di materia* in Constitutional Law. Finally, in 2019 I became a lawyer.

I am currently a PhD student in Legal Science under the guidance of Professor Marco Betzu. My research interests concern Constitutional Law and, in particular, the ways in which political power controls globalized economic power. During my doctoral studies, due to the Covid-19 pandemic, I was unfortunately unable to undertake a period of research abroad in attendance. However, I did a 6-month research period in smart working at the *Institut de droit public, sciences politiques et sociales de l'Université Sorbonne Paris Nord*, under the supervision of Professeur de Droit public Mr. Franck Laffaille.

In the light of my research interests, my doctoral thesis project focuses on the control by state political power of supranational economic policies, specifically those on trade produced by the World Trade Organization. In this regard, in my dissertation I first ascertain the incompatibility between the constitutional model of the so-called “mixed economy” and neo-liberal economic systems, with specific reference to the liberalist theories of the Vienna School and the ordoliberal theories of the Freiburg School. In the light of this observation, through the study of the WTO treaties, I then proceed

to identify the type of supranational economic system in terms of trade and, after ascertaining that it is a form of neo-liberalism in which the social dimension is absent, I note its incompatibility with the Constitution. In view of the incompatibility, therefore, between the constitutional economic system of mixed economy and the supranational neo-liberal one, I wonder about the useful remedies that the state political power has at its disposal to influence the supranational economic power and I identify a possible solution in the implementation of the representation and political responsibility of the member states in the WTO. In conclusion, I point out the usefulness, not only theoretically but also practically, of the study as a possible solution in the fight against globalization phenomena such as social dumping. Although this phenomenon determines negative consequences within individual states, it is precisely because of its global scope that it cannot be effectively countered with legal instruments that produce effects exclusively within states.



PhD programme in Innovation Sciences and Technologies

Coordinator: Roberto Orrù

The International PhD in Innovation Sciences and Technologies has started its activity during the academic year 2013/14, by taking advantage of the positive experience of the International PhD in Environmental Science and Engineering (2001/02 – Cycle XVII to 2012/13 – Cycle XXVIII), first one of this type at the University of Cagliari, as well as the PhD in Biomedical Engineering (2010/11 – Cycle XXVI to 2012/13 – Cycle XXVIII), which are no longer active.

The program of the International PhD in Innovation Sciences and Technologies involves most of the topics related to the latter ones, while introducing new lines of investigation. Three curricula are involved in the framework of this PhD program:

Regenerative medicine and biomedical applications.

Methods and systems for environmental protection.

Methodologies and processes for the transformation and use of materials.

The PhD Committee (a.y. 2020-21, XXXVI cycle) is constituted by the following assistant, associate, and full professors as well as experts in their field (listed in alphabetical order):

Silvia Ajossa, Matthias Angermeyer, Stefano Angioni, Doris Barcellona, Giacomo Cao, Giovanni Caocci, Mauro G. Carta, Maria F. Casula, Alessandro Concas, Antonio Crisafulli, Guido Crisponi, Francesco Delogu, Sandro Demuro, Marina V. Duljasova, Enrico Erdas, Fabian I. Ezema, Gavino Faa, Vassilios Fanos, Stefano Guerriero, Roberta Licheri, Mostafa Maalmi, Valerio Mais, Gian B. Melis, Ana

I. Miranda, Marco Monticone, Giorgio La Nasa, Valeria M. Nurchi, Germano Orru', Anna M. Paoletti, Palmina Petruzzo, Giorgio Pia, Luca Pilia, Massimo Pisu, Giovanni M. Sechi, and Annalisa Vacca.

The enrolled students are supposed, apart from the other requirements established by the [current rules issued by the University of Cagliari](#), to have published or accepted for publication at least two papers in reputable scientific journals, along with their co-authorship as first name, by the time of the presentation of their third year activity.

Some of the recent PhD awarded are reported as follows:

2019/2020

- BLESSING C. EZEALIGO: Fabrication and characterization of barium titanate based ceramic materials
- VIRGINIA PINNA: The cerebral circulation and oxygenation in response to sympathetic stress in ageing and in patients with metabolic disorders
- HEMA SEKHAR REDDY RAJULA: Study of Metabolomic Networks associated with Autism and Schizophrenia
- GABRIELE TRAVERSARI: Analysis of multi-phase systems relevant to bioengineering and materials science

2018/2019

- MARINA LUGININA: Fabrication and characterization of Bioactive / Biodegradable materials for tissue engineering
- GABRIELE MULLIRI: The Effect of Normobaric Hypoxia and Metaboreflex in the Cardiovascular Adjustment to Exercise
- FRANCESCO TORRE: Grain boundary segregation as the process enabling thermodynamic stability in nanocrystalline metal alloys
- ROSITA CAPPAL: Integrate Approach to the Study of Chelating Agents for the Effects of Toxic Metal Ions
- ISKREN KIRILOV TODOROV: Trends of the European Scientific Publications in Comparison with other World Leaders over the Period 2015-2019
- GIOVANNA TALLARITA: Bulk high-entropy metal diborides: processing, characterization, and structure refinement.

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

Home-based EXergames To improve cognitive function in Multiple Sclerosis

Letizia Castelli

Curriculum: Regenerative medicine and biomedical applications



My research activity is mainly based on the assessment and treatment of cognitive and balance disorders in people with Multiple Sclerosis (MS), especially on the use of exergames in rehabilitation.

Cognitive impairment is common in people with Multiple Sclerosis (MS) at any stage of disease. There is no effective pharmacological treatment to manage cognitive impairment in MS: actually, rehabilitation is the only strategy. People with MS have coexisting cognitive and motor deficits and require both cognitive and motor rehabilitation. Therefore, providing a single rehabilitative strategy that can address cognitive and motor issues remains highly desirable.

Exergaming (i.e., playing exergames) is a form of whole-body physical exercise performed through active video games to improve fitness and promoting an active lifestyle. Playing exergames involves not only the hand-eye coordination, but also whole-body physical exertion, with the aim of improving fitness and promoting an active lifestyle. In people with MS, exergames have been reported to be safe in-home setting. There are only few studies investigating the effect of exergames on cognitive function in MS and none designed to test the hypothesis of using exergaming to improve cognitive function in MS. A recent meta-analysis provided data showing how the use of high frequency commercial exergames provided by Wii balance board as supervised or unsupervised rehabilitation tool, in addition or not with other interventions, it can improve balance dysfunction due to neurological diseases. Based on this, the playing/loosening frequency with exergames was established.

Another recent meta-analysis exploring the role of exergames in improving cognitive functions in persons suffering from neurological disabilities (including MS), showed that exergames significantly improved executive functions and visuo-spatial perception when compared to alternative or no intervention.

Furthermore, we hypothesized that the rehabilitation outcome obtained after training with exergames and video games for cognitive rehabilitation can be modulated by premorbid level of enriched physical and intellectual activities, as well as by specific character and temperament traits.

In light of what emerged from the literature and previous studies, the *“Home-based EXergames To impRove cognitivE function in Multiple Sclerosis: the EXTREMUS study”*, aims to determine the efficacy and safety of a new rehabilitation approach that could be used in a home care setting to exploit and promote combined motor and cognitive function of specific brain regions using exergames.

Castelli L., *et al.*, Premorbid functional reserve modulates the effect of rehabilitation in multiple sclerosis, *Neurol Sci* 41(5): 1251-1257 (2020)

Analysis and screening of microalgal strains for advanced biotechnological applications

Giacomo Fais

Curriculum: Methods and systems for the environmental protection



During my studies at the Interdepartmental Center of Environmental Science and Engineering (CINSA), I had the pleasure and the opportunity to learn the ecological, technological, and application importance of green and blue algae (cyanobacteria) and innovative techniques to study their potential.

In fact, these microorganisms, thanks to photosynthesis, use carbon dioxide to produce oxygen and organic compounds. For this reason, they are used in several technological sectors such as food, nutraceutical, cosmetic and environmental sectors, as well as, as far as more futuristic applications are concerned, in Space and on the Red Planet.

During the development of the Ph.D. Thesis "*Analysis and Screening of Microalgal Strains for Advanced Biotechnological Applications*", the attention has been first focused on some extremophilic microalgae isolated in Sardinia and, in the framework of the project COMISAR (Cultivation of Sardinian Microalgal Strains), funded by the Region of Sardinia (POR FESR 2014 - 2020), the microalgae growth and the extraction techniques of high-value compounds have been investigated.

As for these microalgae, the metabolomic profile and the presence of interesting molecules possessing bioactive properties have been addressed.

At the University of the Balearic Islands (UIB), some aspects of cell physiology of cyanobacteria interesting for their ability to withstand extreme conditions and considered as ideal candidates to be used in future space missions has been taken into account. In particular, the mechanisms of using carbon dioxide, the ability to produce oxygen, and

biomolecules such as carotenoids and phycocyanins, in the presence of high concentrations of carbon dioxide has been investigated.

In addition, thanks to the collaboration with the University of Sassari, algae cultivation techniques in the absence of gravity which allow one to simulate space missions have been applied. Additionally, the response of algae to such stress in terms of growth and production of high-value products has been observed.

Finally, I had the opportunity to participate in the development of free-range cultivation tanks to be installed in the Italian Pavilion of Dubai's EXPO 2021 with the aim of bio-fixing carbon dioxide exhaled by event visitors and correspondingly producing oxygen.

Characterisation of cardiac functions with imaging in healthy populations

Sara Magnani

Curriculum: Regenerative medicine and biomedical applications



My interest for cardiovascular and exercise physiology has been started during my first year of resident doctor in Sport Medicine. At the beginning my attentions were focused only on the clinical side of the cardiovascular system, but then my interest for the research area was also stimulated.

This led me to start my PhD in Innovation Science and Technologies at the Sport Physiology Lab, under the supervision of Prof. Antonio Crisafulli. Previously, during my resident period, I have worked on several research projects focusing on the cardiovascular adjustments in response to exercise in healthy subjects as well as in patients suffering from different kinds of diseases (i.e., coronary artery disease, arterial hypertension, multiple sclerosis, metabolic syndrome, type 2 Diabetes Mellitus).

The focus of my research during the period of my PhD was to characterise the cardiac tissue with innovative technique during different type of stressors (i.e., exercise, acute hypoxia) in healthy populations of different age and physical capacity.

In the first research, I worked on certain cardiovascular parameters that are supposed to be particularly sensitive to hypoxia. Specifically, we induced hypoxia using a gas generator (Everest Summit II Generator, Hypoxico, New York, US), which is able to separate nitrogen from oxygen and allows having a gas mixture with a reduced oxygen content that can be regulated by an operator. By employing non-invasive methods (impedance cardiography), I investigated on hemodynamics of young healthy subjects during the activation of the metaboreflex, i.e., a cardiovascular reflex that is pivotal to adjust the

hemodynamics during exercise. Results have been published in a peer-review journal.

In another research, I ascertained whether echocardiographic, Doppler, and tissue Doppler measures were able to detect changes in systolic and diastolic functions immediately after mild bout of exercise in acute hypoxia in healthy individuals. During hypoxia, the human circulation experiences rapid changes in the main hemodynamic modulators (i.e., pre-load, after-load, contractility, and chronotropism), which potentially impact on cardiovascular function and regulation. The main result of the second research was that the hypoxic exercise led to an increase in certain parameters related to myocardial contractility, such as pre-ejection period and systolic myocardial velocity. Moreover, during hypoxia early transmitral filling peak velocity was also increased. Results have been published in a peer-review journal¹.

In the third experiment, I compared during moderate exercise hemodynamics of young subjects with that of aged individuals. I found that the main difference between groups was in the capacity to increase the atrial component of ventricular filling, while early filling was similar between young and aged individuals.

I hope that these results may have a practical impact in the biological and medical sciences.

Magnani S., *et al.*, Systolic and diastolic functions after a brief acute bout of exercise in normobaric hypoxia, *Frontiers in Physiology*, in press (2021)

Fabrication strategies of noble and non-noble nanoporous metals

Andrea Pinna

Curriculum: Methodologies and processes for the transformation and use of materials



I received the master's degree in Physics in Cagliari in 2018 under the supervision of Prof. Carlo Maria Carbonaro. Then, I joined the PhD course of Innovation Science and Technologies under the supervision of Prof. Luca Pilia.

My research interests focus on the development of new strategies for the fabrication of nanoporous metals. The research activity has been performed in the Department of Mechanical, Chemical and Materials Engineering (DIMCM) and, during my period abroad, at the BESE Division of King Abdullah University of Science and Technologies (KAUST), Saudi Arabia, where I also had been trained in the use of conventional and advanced electron microscopy techniques under the supervision of Prof. Andrea Falqui.

Among the wide class of nanomaterials, nanoporous materials are of great interest for different applications, ranging from biomedical to energy storage and conversion ones. Nanoporous metals are nanoporous metallic materials made of interconnected ligaments and pores with characteristic sizes of no less than 200 nanometers (nm). They can have a series of very important applications related to the coupling of the common properties of bulk metals and those of nanostructured ones. However, their fabrication is still challenging and needs to be improved in order to overcome some fundamental problems: nanoporous metals are commonly brittle and their nanostructure ligaments and pores tends to coarse when subjected to temperatures as low as 100°C; non-noble nanoporous metals are very challenging to be produced, factor that limits the applications spectrum for the high costs of noble metals. For these reasons, my PhD thesis is focused on the *Fabrication Strategies of Noble and Non-Noble Nanoporous*

Metals, strategies aimed to overcome these common problems. Nanoporous metals can be fabricated by the selective removal of one or more elements of an alloy, in a process called dealloying. The most common method is the chemical dealloying, where a more reactive metal can be removed from an alloying, while the more noble metal atoms can diffuse and recombine in an interconnected network of ligaments and pores. This method is quite efficient for the fabrication of noble nanoporous metals. We used this method in order to study the dealloying mechanism of nanoporous gold and nanoporous copper in different conditions by means of Scanning Electron Microscopy (SEM) measurements. Moreover, we achieved for the first time the fabrication of nanoporous aluminum (NP Al) through a different dealloying method, the Vapor-Phase Dealloying, which consists of the selective sublimation of zinc from a precursor Al-Zn alloy. NP Al presents nanostructured ligaments and pores of different length scales, from few to thousands of nm, and a very high surface area. A material with such characteristics can be suitable for a wide range of applications, from UV sensing and catalysis to the use as a low-density and low-cost structural material.

Evaluation of beach-cast litter influence on coastal morphodynamics

Daniele Trogu

Curriculum: Methods and systems for environmental protection

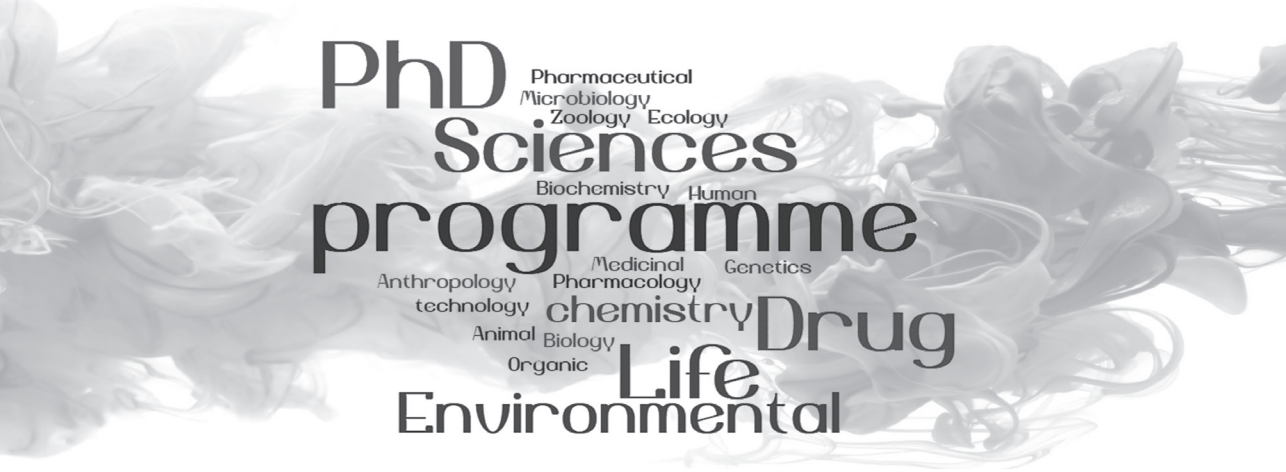


The studies carried out to realize my PhD thesis (*Evaluation of beach-cast litter influence on coastal morphodynamics*) are part of the research activity on the coasts and on the continental shelves done by the Coastal and Marine Geomorphology Group (CMGG, Scientific Coordinator: Prof. Sandro DeMuro), belonging to the Department of Chemical and Geological Sciences of the University of Cagliari and MEDCOASTLAB (Mediterranean Geomorphological Coastal and Marine Laboratory) which aim to improve the knowledge useful for the study, protection and management of mediterranean microtidal wave dominated beaches by increasing the resilience of the beach system within the global climate change scenario (goals 13-14-15 of the UN 2030 Agenda). Data collection was made possible by the projects PROVIDUNE (LIFE07NAT/IT/000519), NEPTUNE and NEPTUNE2 (“Natural Erosion Prevision Through Use of Numerical Environment”; Scientific Coordinator: Prof. Sandro DeMuro). Thanks to this last project, which supported me during the three years, I was able to take advantage of important national and international collaborations such as The University of Auckland, through Prof. Giovanni Coco (my co-tutor). At this University I am currently carrying out the six-month research period abroad, in smart-working, due to the SARS-CoV-2 pandemic. Thanks to this experience it has been possible to process the high-resolution video-based data in an innovative way, achieving a better knowledge of coastal morphodynamic processes such as wave run-up and the role that biomasses (*Posidonia oceanica* *banquette* and other organic material such as remains of *Arundo donax*) have in the mitigation of the impacts caused by the wave motion.

The high-resolution video-based data consist of two distinct databases: 1) two years of acquisition from the system installed on the Piscinnì beach; 2) four years from the system installed on the Poetto beach. The analysis and interpretation of the images of the first database made it possible to determine the morphodynamic states during the most significant storm events. Subsequently, it was possible to measure the oscillation of the shoreline before, during and at the end of the storm, by the rectification and georeferencing of the images. The results highlighted the remarkable progradation, also caused by the deposition of the banquette, after about 48 hours from the end of the storm event. With the second database we proceeded to measure the extensions of the banquette along three land-sea transects located in areas with different anthropogenic impact, to analyze how and when the deposition of the biomasses occurs, their permanence and dismantling and how these can interact with the wave motion and reduce the flooding hazard. To refine this last point, high-precision topographic and bathymetric surveying campaigns (DGPS surveys, drone surveys, single beam surveys) and permeability tests along the beach were carried out. Thanks to these data also the warning system, linked to the flooding hazard for the Poetto beach, has been improved.

An important research work done during my PhD is:

Trogu D., *et al.*, What Happens to a Mediterranean Microtidal Wave-dominated Beach During Significant Storm Events? The Morphological Response of a Natural Sardinian Beach (Western Mediterranean), in: Malvárez, G. and Navas, F. (eds.), *Global Coastal Issues of 2020. Journal of Coastal Research*, Special Issue No. 95, pp. 695-700. Coconut Creek (Florida), ISSN 0749-0208



PhD Sciences programme

PhD programme in Life, Environmental and Drug Sciences

Coordinator: Simona Distinto

Vice-coordinator: Enzo Tramontano

The PhD program in Life, Environmental and Drug Sciences allows the student to work in a multidisciplinary environment with a broad spectrum of interests and research objectives. It is organized 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 collaborations among the curricula allow the students to consider different aspects involved in the life sciences.

The PhD Board involves 28 qualified Professors of the Department Life and Environmental Sciences with multidisciplinary expertise and international collaborations. In alphabetical order: Elio Acquas, Gianfranco Balboni, Tiziana Cabras, Carla Maria Calò, Caddeo Carla, Rita Cannas, Angela Corona, Filippo Cottiglia, Danila Cuccu, Francesca Esposito, Giovanna Delogu, Simona Distinto, Antonella Fais, Anna Maria Fadda, Maria Cristina Follesa, Francesco Lai, Elias Maccioni,

Barbara Manconi, Maria Manconi, Elisabetta Marini, Rosaria Medda, Alessandra Olianias, Valentina Onnis, Francesca Pintus, Antonio Pusceddu, Chiara Sinico, Enzo Tramontano and Carlo Tuberose.

The PhD Board activated international conventions with an Asian University (Taipei Medical University) and a European University (University of Porto), which will allow doctoral students to acquire a double international degree.

The PhD students, at the end of the program, obtain high competencies in their investigational areas, complete judgment autonomy, adequate communication skill, high ability to learn new information and apply new technologies to one of the listed research areas.

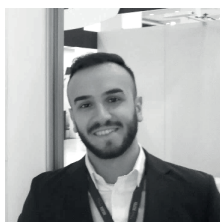
XXXIV cycle doctoral students are all highly motivated and acquired autonomous capability to accomplish original research projects on the topics covered by the PhD programme. They are going to complete their course with an enriched CV, which includes several publications, seminars, summer schools, national and international conference participation. In these three years, they have carried out teaching support tutoring activities in various courses of the Biology and Pharmacy Faculty. Their the research activity took place both in Cagliari and at foreign institutions, although SARS-CoV2 epidemic slowed down the regular research activity. In particular, they had the opportunity to work at University of Ljubljana, University of Santiago de Compostela, University of Aveiro, and Max Planck Institute in Munich.

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

Delivery of a corticosteroidal nanosuspension via electronic cigarette

Luca Casula

Curriculum: Drug Sciences



Luca graduated with honours in Pharmaceutical Chemistry and Technology in 2018 at the University of Cagliari, with an experimental thesis entitled “Prolonged release of antibiotics from double layer nanofibers for local periodontitis treatment”. The research for his Master’s thesis, whose results have been published in a scientific journal, was carried

out at the Faculty of Pharmacy of Ljubljana, under the supervision of Professor Julijana Kristl and Assistant Professor Špela Zupančič, and the home mentorship of Professor Anna Maria Fadda. After his degree, he spent a period of three months at the Semmelweis University of Budapest, where he worked on the formulation and characterization of nanofibrous delivery systems, under the supervision of Professor Romána Zelkó.

In October 2018 he joined the PhD Program in Life, Environmental and Drug Sciences (Drug Sciences Curriculum) at the University of Cagliari, under the supervision of Prof. Anna Maria Fadda. As a continuation of the collaboration established during his Master’s Thesis project, he joined the research group of the University of Ljubljana as a visiting PhD student in 2019, in order to study and develop a liposome-loaded nanofibrous scaffold for the wound healing.

His PhD thesis is focused on the *development of innovative nano-formulations with anti-inflammatory agents*. Particular interest is addressed to the study of the electronic cigarette as an alternative medical device for the delivery of drug nanosuspensions. Electronic cigarettes - or e-cigarettes - are marketed as aerosol producing devices for the delivery of tobacco-free nicotine. Since the tobacco combustion is avoided, they appear to be safer than conventional cigarettes. However, metal and silicate particles – including nanoparticles – have been

found in cartomizer fluid and aerosol produced by some e-cigarettes made of low quality materials. Therefore, considering that the ability of the aerosol produced by e-cigarettes to transport nanoparticles has been demonstrated, we investigated its ability to deliver nanocrystals of poorly water-soluble drugs. Nanocrystals are nanoparticles of pure drug, prepared as colloidal nanosuspensions, in both water and non-water media, stabilised using surfactants or polymers.

A nanocrystal nanosuspension of **beclomethasone dipropionate**, a synthetic chlorinated corticosteroid diester commonly used by inhalation in the treatment of asthma and chronic obstructive pulmonary disease, was prepared through a wet media milling technique using Poloxamer 188 as stabilizer. The nano-formulation was fully characterized, showing optimal physico-chemical properties, such as drug crystals diameter in the nanometer range, homogenous size distribution, mid-term stability and increased drug solubility compared to the raw drug. The formulation was then freeze-dried and loaded in the cartomizer of the electronic cigarette and the produced aerosol was collected and analysed, confirming the presence of drug nanocrystals.

This study showed that e-cigarette might be used as a medical device to deliver pharmaceutical formulations prepared through nanotechnologies, such as nanosuspension, in order to improve the bioavailability of poor soluble drugs.

Casula L., *et al.*, Delivery of beclomethasone dipropionate nanosuspensions with an electronic cigarette, *International Journal of Pharmaceutics* 596: 1-9 (2021)

Different proteomic approaches on saliva of Alzheimer's disease subjects

Cristina Contini

Curriculum: Biomedical



I joined the XXXIV cycle of PhD in Life and Environmental Sciences in 2018 after Bachelor's graduation in Toxicology and Master's graduation in Cellular and Molecular Biology. Since 2015 I started learning about Liquid Chromatography coupled with Mass Spectrometry (LC-MS) applied to proteomics studies. During my research activity I had the chance to spend 4 months at the Mass Spectrometry Center of University of Aveiro (Portugal) through Erasmus+ program and 8 months at the Max Planck Institute of Psychiatry in Munich (Germany) as an integral part of my PhD project. Both experiences have been extremely helpful to learn new techniques and laboratory skills, but also to develop a deep critical mind-set as a scientist. At the University of Cagliari, I work under the supervision of Professor Tiziana Cabras, head of the Proteomics Lab in the Biomedical section of Department, who entrusted me with a project focused on the characterization of proteomic changes in the salivary profiles of Alzheimer's disease patients in comparison with healthy subjects. Through the years, my research group in Cagliari has deeply investigated the proteomics of human saliva, which appears to have high potential as prognostic and diagnostic biofluid for the research of candidate biomarkers of diseases. In fact, quali-/quantitative changes in salivary proteins and peptides may mimic and reflect physio-/pathological conditions of the same proteins and peptides expressed in different organs and tissues, including the brain. Therefore, the first goal described in my PhD thesis *"HPLC-MS based proteomics to investigate the salivary protein profile of Alzheimer's Disease"*, has been to study the presence of any quali-/quantitative difference between Alzheimer's disease patients' group and healthy controls' group, age

and sexed matched, with a Top-Down proteomic approach. Indeed, Alzheimer is the most common neurodegenerative disorders of the elderly, so it has also been crucial to recruit a coherent cohort of controls and to determine the “normal” salivary protein profile in the elderly with respect of a cohort of non-old adult controls. This part of the PhD project highlighted an over expression of proteins and peptides involved in inflammation, antioxidant activity and response to bacteria in Alzheimer’s diseases subjects. Among them, cystatin B appeared to be particularly interesting to proceed with further investigations. This protein is one of those measurable in saliva that is also expressed in the brain and widely distributed in many different cell types. It works as intracellular reversible inhibitor of proteases, but it has also been found involved in proliferation, interneuron migration and protection against oxidative stress with capacity of forming homo- and hetero-aggregates that has been linked to Alzheimer’s disease. Considering that other cystatins, like cystatin C, show amyloidogenic properties, the second goal of my PhD project has been the characterization of potential multi-protein aggregates involving cystatin B in saliva. In this case the experimental strategy included a Co-Immunoprecipitation assay followed by in gel digestion and high resolution nanoHPLC mass spectrometry. This Bottom-Up proteomic approach allowed the characterization of ca. 30 proteins able to interact with cystatin B in saliva and deeply involved in the immune system, including cystatin C, cystatin D, members of S100A family proteins, integrin alpha M and others. Some of them were found to be quantitatively different between the patients’ and the controls’ groups, confirming the potential in salivary proteomic investigations and the existence of differences in proteins’ ratios and composition between Alzheimer’s disease subjects and healthy controls.

Contini C., *et al.*, Top-down proteomics of human saliva highlights anti-inflammatory, antioxidant and antimicrobial defense response in Alzheimer disease, *Front Neurosci*, 15: 478 (2021) doi: 10.3389/fnins.2021.668852.

Reproductive biology and ecology of the sea cucumber *Holothuria tubulosa*.

Viviana Pasquini

Curriculum: Animal and Human Biology, and Ecology



Born in Cagliari in 1990, I received my Master's Degree in Marine Bio-ecology *Cum Laude* at the University of Cagliari in 2017. Afterwards, I held a fellowship in the framework of the project "Innovative species of commercial interest for Sardinian aquaculture: development of experimental protocols for holothurians rearing and their sustainable exploitation" funded by the European Maritime and Fisheries

Fund (EMFF) EU program. Following this experience, my PhD thesis, entitled "*Reproductive biology and ecology of the sea cucumber, Holothuria tubulosa* Gmelin, 1788", has dealt with the reproduction biology and ecological role of the deposit-feeder sea *Holothuria tubulosa* Gmelin 1788, one of the most common sea cucumbers in the Mediterranean Sea, on benthic biogeochemistry and trophodynamics.

Sea cucumbers, as being among the major responsible of benthic bioturbation processes, play a putative key role in sedimentary nutrient cycling and coastal benthic trophodynamics. *H. tubulosa* has been for years one of the sea cucumbers most actively harvested in Turkey, Greece, Italy, Spain with the aim of export to the Eastern Asian markets where they are sold as gourmet seafood. These practices have severely abated sea cucumbers stocks, at the point that the Italian Government has recently prohibited their harvesting.

To provide support to the need of urgent conservation and protection practices of sea cucumbers, I explored the role of *H. tubulosa* in the transformation of sedimentary organic matter (OM) and investigated changes in quantity, biochemical composition and bioavailability of sedimentary OM in grounds typically hosting sea cucumbers. I also investigated the fate (and degradation) of OM ingested by *H. tubulosa*

to estimate their potential use in ecological restoration of eutrophicated sediments (like those beneath mariculture plants), by profiting of their bio-digestion potential.

The major results obtained so far confirm that these organisms behave as bioreactors able to accelerate sedimentary OM transformations, facilitating nutrient cycling, thus potentially ameliorating the overall environmental quality of eutrophicated marine bottoms.

As a corollary, I also improved the current knowledge about the reproduction biology of *H. tubulosa*. More in details, by means of manipulative experiments carried out to identify the best protocol for *ex-situ* sea cucumber reproduction, I investigated the effects of different environmental conditions on the maturation process of gametes in adult specimens from different locations, along the Sardinia coasts. Once identified the reproductive season after one year-long monitoring survey, I exposed sexually mature sea cucumbers to different physical and chemical stimuli to trigger artificially their spawn. The best outcome was obtained with an exposure to mechanical stress. The healthy gametes obtained in the laboratory, have been then used in further manipulation experiments to identify the best conditions for larval growth, metamorphosis, and settlement, and growth of juveniles *H. tubulosa*. The results of these experiments are in the way of formal analysis.

Part of the results have been included in the technical report of the EMFF project and presented at the Annual Meeting of Ecology and Science of Aquatic Ecosystems PhD students (Naples, April 2021) and at the XXV Congress of the Italian Association of Oceanography and Limnology (June 2021).

Exploring the pharmaceutical profile of furobenzopyrone derivatives

Lisa Sequeira

Curriculum: Drug Sciences



Lisa Sequeira completed the Degree and the Master's Degree in Chemistry at the Faculty of Sciences, University of Porto, Portugal, in the years 2011 and 2013, respectively. After the successful conclusion of her MSc Lisa integrated different research groups in more than one institution of Portugal, which expand her knowledge in several areas of chemistry and in research.

In 2018 Lisa joined the XXXIV PhD Cycle with a scholarship funded by MIUR, under the supervision of Prof. Elias Maccioni. With this PhD she was able to achieve a long-standing goal, the opportunity of doing research abroad. With her scholarship she was able to spend 18 months in Cagliari and 18 months at the Department of Organic Chemistry, Faculty of Pharmacy of the University of Santiago de Compostela working under the supervision of Prof. Eugenio Uriarte.

Her current research is based on the development of furobenzopyrone derivatives with potential biological activity.

Cancer is one of the leading causes of death and failures in the treatment of metastatic disease and the development of drug resistance are the main reasons for this high mortality rate.

Carbonic anhydrases (CAs) are metalloenzymes involved in several physiological processes. These enzymes are divided according to localization and tissue distribution. CA IX and CA XII are two membrane-bound CAs mainly associated with and overexpressed primarily in hypoxic tumours, being involved in critical processes connected with cancer progression and response to therapy. Inhibition of these tumour-associated enzymes by many classes of inhibitors (e.g. sulfonamides, coumarins) has been shown to halt the proliferation of

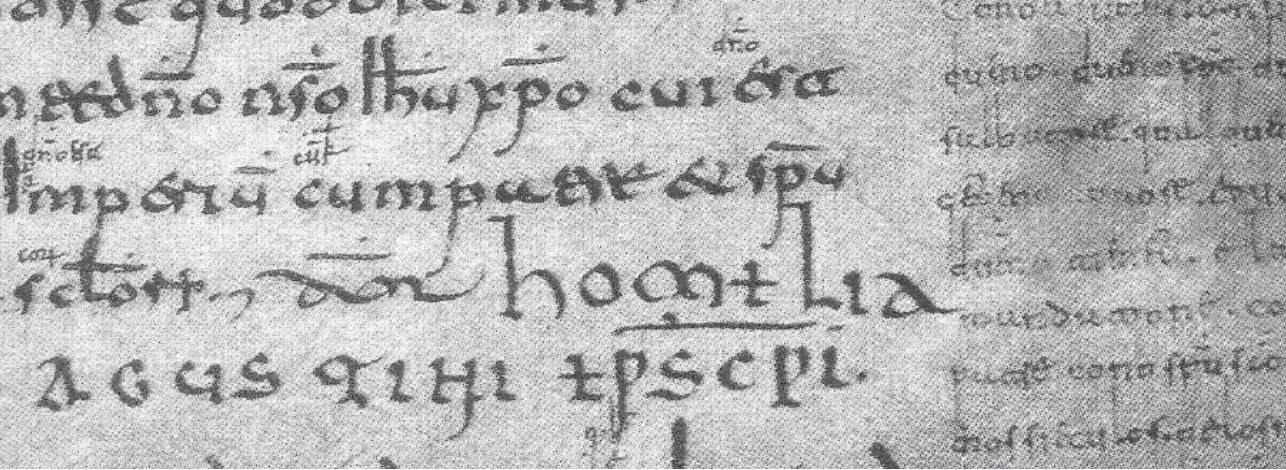
cancer cells in vitro and to inhibit metastasis and reduce population of cancer stem cells. Furthermore, combination of such inhibitors with conventional chemotherapy or radiotherapy has also been demonstrated to inhibit the growth of several tumours.

Therefore, CA IX and CA XII are attractive therapeutic targets principally for two factors. First, both isoforms have a targetable, extracellular catalytic domain. Secondly, the limited expression of CA-IX in healthy tissue reduces possible side effects that may occur due to inhibition in off-target tissues. Hence, targeting CA IX and CA XII in cancers that overexpress these biomarkers may be proved to be therapeutically beneficial in the treatment of cancer. For these reasons, CAs attracted an increasing interest from researchers as drug targets.

Coumarins and chromones are two groups of naturally occurring heterocycle compounds widely distributed in nature. Their chemical and biological aspects have been studied in detail. Molecules containing the coumarin and chromone skeleton have a wide variety of biological activities such as antiviral, antimycotic, and antitumor. Moreover, the ability of coumarin and psoralen derivatives to inhibit human CAs IX and XII has also been reported also by our group.

On this basis, we aimed to develop two libraries based on coumarin, chromone and benzensulphonamide derivatives as CAIs, designed to meet the structural and pharmacokinetic requirements to selectively inhibit the specific CAs isoforms associated with cancer.

Distinto S., *et al.*, Exploring new structural features of the 4-[(3-methyl - 4 - aryl - 2,3 - dihydro - 1,3 - thiazol - 2- ylidene) amino] benzenesul - phonamide scaffold for the inhibition of human carbonic anhydrases, *Journal of Enzyme Inhibition and Medicinal Chemistry* 34(1): 1526-1533 (2019)



PhD programme in Philological and Literary, Historical and Cultural Studies

Coordinator: Mauro Pala

Vice-coordinator: Tiziana Pontillo

The International PhD Programme in Philological and Literary, Historical and Cultural Studies, in collaboration with The University of Edinburgh and Uniwersytet Jagiellonski w Krakowie, aims at providing doctoral-level education in literature today, investigating the intertwining of literature, society and the media, and, at the same time, tracing the formal and thematic genealogy of the Humanities in classical and modern Western literature and Indology. The study of literature is conceived as the combination of philology and history, while particular emphasis is placed on innovative critical perspectives and venues, such as postcolonial, cultural, and gender studies, as landmarks of current transnational hybridization and intertextuality. Within a globalized background, we offer a Curriculum focused on Literature from Antiquity to Renaissance and a Curriculum on Modern and Contemporary Literatures related to their critical contexts.

The classical Curriculum, which provides for a philological and exegetical approach to ancient up to medieval and Renaissance texts, includes Sanskrit Language and Literature, Ancient Greek Language, Literature, History of classical institutions and Thought, Latin Language and Literature in Ancient Rome, Early Christian Literature, Romance Philology.

The modernist Curriculum focuses on Anglo-American Literature, Comparative Literature, British Literature and Literatures in English, French Literature and Literatures in French, Iberic Spanish Literature, German Literature, Hispanic American Literatures, Italian Literature from the 13th Century up to the present, History of Theatre and Drama. PhD students admitted to the XXXVIII cycle will spend at least six months abroad, carrying out their research in selected academic institutions where experts in the field will supervise their investigations, working closely together with their home tutor. This will help to widen their scope and encourage a fresh attitude towards literary phenomena as a complex and often shifting field of cultural production. The interdisciplinary nature of the programme not only fosters a comparison between literature and media, from ancient manuscripts to hypertexts and visual artefacts, but also allows the potential of cultural expressions in their technological development and pedagogical implications to be gauged.

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

A Study of the homometric occurrences in ancient Greek strophic poetry

Alessio Faedda



Alessio Faedda, born in 1993, graduated with honours in Classics at the University of Cagliari in 2018 with a dissertation titled *For a Study of the Homometric Occurrences in Greek Archaic and Classical Strophic Poetry* under the supervision of Prof. Tristano Gargiulo. He is currently attending the International PhD Course in Philological and Literary, Historical and Cultural Studies at the same University under the supervision of Prof. Tristano Gargiulo (University of Cagliari) and Prof. Michele Napolitano (University of Cassino). In 2019-2020 he spent five months as a visiting researcher at the University of Barcelona under the supervision of Prof. Xavier Riu i Camps. He is “cultore della materia” in Greek language and literature (L-FIL-LET/02) at the University of Cagliari. He has a keen interest in ancient music, especially Baroque music and sings as a tenor in the vocal ensemble “RicerCare” and in the choir “Musica Viva Cagliari”.

He is currently carrying out research on the homometric occurrences in Greek archaic and classical strophic poetry. This is a metrical and semantical feature consisting in the exact return of nouns, verbs, conjunctions or other parts of speech, oppositions, syntactic parallelisms, or phonic similarities in the same place of the metrical pattern of a strophic composition. It seems to be founded on the poetic tool of repetition, which reveals itself in multiple realizations among the techniques a poet can use. Metrical responson grants that the poet's intention is almost certain, aiming to stress keywords and central ideas of a choral song, strengthen the web of the ode's meanings and give the ode an accurate construction through symmetries and parallelisms. Music could provide a suitable support to the identification of the feature to the ears of the audience, but that is a *vexata quaestio*. According

to Dionysius of Halicarnassus, melody did not vary between a strophe and its antistrophe, but the same passage could allude to the maintaining of the same harmonic genre in a strophic couple, as well. Moreover, the role of word-accents in shaping a melodic line in a musical language such as ancient Greek is still under discussion. However, homometric occurrences prove to be frequently used in all the principal authors of archaic, late archaic and classical period, both in fragmentary poetry and best-preserved texts: Alcaeus (17), Alcman (5), Stesichorus (10), Ibycus (3), Simonides (1), Pindar (93, without considering fragments), Bacchylides (35), Aeschylus (83), Sophocles (76), Euripides (27 in three tragedies out of nineteen). The high figures shown in initial and final verse position are probably connected with the fact that they are the initial and final moment of a sound experience and also due to the care archaic authors reserved for poems. Interestingly, despite such pervasiveness, detailed studies are lacking. Except for a few works from the late 19th century and some observations from the 20th century, Greek metric handbooks point out the phenomenon without tentative explanations or denominations, when the possibility of parallelism between metrical structure and thought in an ode is not stressed. But homometric occurrences seem to be relevant and useful in composing, analysing and understanding a strophic poem, where not only do they underscore relevant ideas by stressing keywords and harmoniously fit in the literal and sound architecture of the composition, but also enhance the chorus's participation in the action and their relationship with the actors, at least in dramatic contexts. Taking them into account when commenting on an ode would improve the overall understanding of ancient poetry, based on the close relationship between music, word and dance.

Faedda A., Alcuni esempi di occorrenze omometriche nel teatro del V secolo a. C. In: Albanese A, Arpaia M. *Linguaggi, esperienze e tracce sonore sulla scena*. Ravenna: Longo Editore; 2020. 71-78.

Ancient language and modern literature

Marta Karcz



Marta Monika Karcz (née Musiał) was born in Ostrowiec Świętokrzyski in Poland. She received her BS and MS degrees in Indology from The Jagiellonian University in Cracow, Poland in 2014 and 2017, respectively. She is currently pursuing her PhD degree under the supervision of Prof. Tiziana Pontillo (University of Cagliari) and Prof. Lidia Sudyka (The Jagiellonian University). During the PhD programme Mrs. Karcz visited the École française d'Extrême-Orient in Pondicherry, India (with a short visit to The Bhandarkar Oriental Research Institute in Pune, India) and a brief period at The University of Tübingen, Germany. She had the opportunity to work and learn from renowned Sanskrit scholars. Her research interests mainly concern contemporary Sanskrit writings, kāvya, Sanskrit drama and the Sanskrit literary theory.

Her research project titled *Vijayāṅkā, Vikāṭānitambā, Avantisundarī – modern Sanskrit dramas of V. Raghavan in the context of contemporary Sanskrit literature* concerns modern Sanskrit literature. Although Sanskrit is often referred to as an ancient Indian language, it has never ceased to be a medium of literature. Ms. Karcz therefore decided to explore the output of the 20th-century Indian scholar Dr. V. Raghavan. He is widely known as an author of numerous books and papers primarily on Sanskrit aesthetics, musicology, and drama. However, he was not only an expert in literature but also a writer himself. Dr Raghavan created poems and plays in Sanskrit and Tamil – his mother tongue. He successfully published and even staged some of his works. In order to propagate Sanskrit theatre and Sanskrit as a spoken language he formed an association called Samskrita Ranga in 1958. With a group

of enthusiasts, he staged several Sanskrit plays, including some of his own works, on both the traditional stage and on the radio.

Three short plays of his authorship were chosen as the focus of the thesis. They all share a common subject – each of them is about an ancient Indian poetess writing in Sanskrit. Vijayāṅkā, Vikāṃanitamā and Avantisundarī were significant names in the realm of Sanskrit poetry. Regardless of the fact that none of their poems was preserved in its full length, their works were quoted in several treatises on Sanskrit poetics. This proves that their literary output was valued by theoreticians of Sanskrit literature. Dr. V. Raghavan also used some of their preserved works and wove them into the structure of the plays. All these dramas also deal with issues of Sanskrit aesthetics. There is no doubt that Dr. Raghavan's literary output blended his poetic creativity with his scientific knowledge and attitude. In his works, the scholar mixed traditional elements of Sanskrit drama with innovations that made the plays more appealing to a modern reader. Through his plays, Dr. Raghavan tried to popularise knowledge on different subjects like Sanskrit poetics, musicology, dance, history. The plays are addressed to educated readers, who know Sanskrit and can appreciate them, but at the same time, Dr. Raghavan used them to popularise Sanskrit literature in the contemporary world.

Although Ms. Karcz's thesis mainly focuses on three of Dr. Raghavan's plays, she investigates them in a much broader context of modern Sanskrit literature in order to explore and define tendencies present in contemporary Sanskrit writings. She tries to determine how the modern Sanskrit authors employ the traditional literary conventions and rules set by theorists of Sanskrit literature, and what innovations they introduce.

A new milestone in the medieval visionary literature of allegorical voyages

Andrea Macciò



Within the framework of the PhD course in Philological and Literary, Historical and Cultural Studies, I have devoted my research work to the philological investigation and the realization of the first critical edition of the *Voie d'Enfer et de Paradis*, the only composition attributed to Pierre de l'Hôpital, which dates from the first third of the fourteenth century and belongs to the ancient French visionary tradition of allegorical journeys to the afterlife (7608 verses). The realisation of this exciting project, now reported in a PhD thesis entitled *Pierre de l'Hôpital's Voie d'Enfer et de Paradis. A Critical Edition and Study of the Dynamics of Transmission and Re-elaboration of a Fourteenth-Century Text*, began with the retrieval and transcription of digital copies of the four manuscript witnesses of the poem. The comparison and collation of the different extant copies made it possible, on the one hand, to demonstrate their provenance from a single lost copy (the antigraph) and, on the other, to establish the most plausible genealogical relationships among the witnesses themselves. Thus reconstructed, the history of the textual tradition proved indispensable for identifying which manuscripts handed down the composition in the most reliable form, i.e., closest to the original. The resulting critical edition proposes several conjectures aimed at repairing the various alterations to the text that have occurred through time. My PhD thesis also includes extensive investigations into the poem's peculiar narrative and semiotic structure, as well as its literary and historical-cultural context, with particular attention both to the study of the sources and to the processes of re-elaboration and theatricalization to which the same poem was subjected in the second half of the 14th century, by two of its unedited rewritings. The critical

edition contains two critical apparatuses. The first reports the rejected variants of the base manuscript (that is the Paris, BnF, fr. 1543, ff. 99v^a-151r^b), while the second collects all the variant readings reported by the manuscript tradition, whether they are substantial or merely formal. Moreover, I include a substantial commentary on the composition related to the sources cited or reused by the author, the themes and topics of particular relevance from a cultural, anthropological, and literary point of view, and necessary bibliographical references. Lastly, I have drafted a complete glossary, including all the words of the poem, the relative inflected forms, the graphic variants, and the verses relevant to each attestation. Most of the results of my research work are already available or are awaiting publication in specialised scientific journals, conference and seminar proceedings, or miscellanies of studies: among them, for example, my paper “La ‘Voie d’Enfer et de Paradis’ di Pierre de l’Hôpital: tra canone e riscrittura”. *Studi Francesi*, 2019; 189 (LXIII | III): 496-514.

These years of doctoral research have offered me the most fruitful and exciting experiences I have had in my academic career. My study abroad period, which took place in Paris thanks to a one-year agreement with the *École Pratique des Hautes Études*, proved to be essential not only to the success of my research work, but also and above all to the human and professional growth that I had hoped for when embarking on the project of the PhD. Of the many rewarding activities made possible during this period in France, I am particularly grateful to have had the opportunity to speak during the seminar *Héros et Vilains*, organised at the *Sorbonne nouvelle* University by *Questes. Groupe de jeunes chercheurs médiévistes*. Moreover, among other activities, the chance to attend the master course in Romance philology at the *EPHE* as well as a course specifically devoted to the edition of medieval texts held at the *École nationale de Chartes* certainly contributed to increasing my knowledge of the various working methods and of the critical issues related to the philological study and edition of a medieval text.

The revision of the Neoliberal concept of human nature in the science fictional Utopias of 1970s

Francesco Nieddu



I took both my bachelor's and master's degree at the University of Cagliari with two theses in comparative literature. The fascination for this critical perspective brought me to study the potentialities of genre literature, specifically science fiction. After the publication of a paper on Clifford Simak, I decided to continue to work on the same theme for my PhD. As a student in the Doctoral Program in Cagliari, I

participated in many activities, courses and seminars, published the paper "Symbiosis and telepathy as biological basis of utopia in Olaf Stapledon's *Last and First Men*" followed by an online presentation on the work of Joanna Russ. I spent my research semester abroad in the United States, at the Manoa University of Hawaii, where I had the opportunity to work under the supervision of Professor John Rieder, one of the most competent and influent scholars in the field. I participated in the various activities proposed by the English department. Discussions in conferences and reading groups among science fiction scholars were particularly stimulating and expanded my knowledge on science fiction literature and theory. Notwithstanding the ensuing pandemic that severely limited all on campus activities, I managed to illustrate my research to the colleagues thanks to an on-line call.

The aim of my research *The Revision of the Neoliberal Concept of Human Nature in the science fictional Utopias of 1970s* is to demonstrate how the most significant utopias of the Seventies anticipate some of the key themes of contemporary philosophical posthumanism through a radical revision of the humanistic notions of humanity and human subjectivity. I selected five texts: *Ecotopia* (1975) by Ernest Callenbach;

The Word for World is Forest (1972) and *The Dispossessed* (1974) by Ursula Le Guin; *The Female Man* by Joanna Russ (1975) and *Women on the Edge of Time* (1976) by Marge Piercy. The focus of the research is the challenge that each text poses to the vision of the human being implicit in the ideology of neoliberalism that was culturally dominant in that period. In Western thought the human has historically been inscribed on a hierarchical scale with respect to the non-human realm. This symbolic structure has not only supported the primacy of humans over animals and the domination of the natural environment but has also shaped the human sphere itself with sexist, racist, classist, homophobic, and ethnocentric assumptions. Drawing from the ideas of post-structuralism, deconstructionism, ecology and feminism, those texts overthrow these assumptions, or some of them, blurring the traditional boundaries between humanity and environment, culture and nature, human and non-human (animal and machine), man and woman. My aim is, on the one hand, to examine the antagonistic concept of human nature displayed by each text and, on the other, to gauge the consistency between the content and form, that is, to check the different efficacy of the literary strategies deployed by each text in conveying the implications – political, social, and psychological – of an alternative vision of humanity. I maintain that a proper posthuman perspective is better conveyed by the fundamental mediation of feminist writers who radically transformed narrative conventions of both the traditional literary utopia and science fiction. The female authors in particular use conventional SF tropes such as parallel worlds, alternative futures and planetary colonisation to open up utopia and put it into a dynamic interaction with other alternative societies. Utopia is then presented as an ongoing process constituted by a multiple agency of different subjects. Both these narrative strategies and the meditation on the potential of technology to radically transform human biology reveal the artificiality of social norms and the possibility of change. Within this frame the human subject loses the status of an autonomous and absolute entity and is instead conceived as a relational node in a network of relationships with other entities.

Index of names

- AL ZAHRA SANAI DASHTI, Zohreh, 87
ATZORI, Massimo, 37
ATZORI, Rossella, 177
AYMERICH, Francesco, 93
BALDASSARRE, Alessio, 179
BANNI, Sebastiano, 123
BARBAROSSA, Stella, 39
BATTAGLIA, Daniele, 71
BLEČIĆ, Ivan, 53i
BONFIGLIOLI, Riccardo, 149
CAMBA, Giacomo, 181
CANNAS, Carla, 3
CARA, Fabrizio, 73
CARRERAS, Marco, 75
CASTELLI, Letizia, 201
CASULA, Laura, 183
CASULA, Luca, 213
COA, Roberta, 137
CONTINI, Cristina, 215
CORRIGA, Andrea, 109
CORSI, Sara, 139
CORSO, Silvia, 191
CUCCU, Sara, 55
D'ALELIO, Umberto, 159
DATILO, Delia, 41
DE AGOSTINI, Antonio, 21
DEHNAVI, Parichehr Yarahmadi , 187
DEIDDA, Roberto, 53
DEMURO, Gianmario, 191
DEMURTAS, Valentino, 23
DISTINTO, Simona, 211
FADDA, Paola, 135
FAEDDA, Alessio, 223
FAIS, Giacomo, 203
FARRIS, Stefano, 57
FARRU, Gianluigi, 25
FLORE, Stefania, 193
FLORIS, Alessio, 59
FUNDONI, Marta, 185
GAO, Chao, 77
GHIGLIERI, Giorgio, 19
GIUA, Alessandro, 69
GRABARA, Piotr Dariusz, 43
GU, Chao, 79
GUERRIERI, Alice, 151
IACOMINI, Antonio, 5
IBBA, Antonella, 7
KARCZ, Marta, 225
LAI, Eleonora, 125
LAN, Hao, 81
LEUZZI, Alessandra, 195
LICHERI, Fabio, 95
LIU, Fang, 161
LODI, Matteo Bruno, 83

- LOI, Gabriela, **97**
LONI, Alessandro, **163**
LUCIANO, Erica, **45**
MACCIÒ, Andrea, **227**
MAGNANI, Sara, **205**
MALLOCI, Francesca Maridina, **111**
MANCA, Elias, **127**
MARCHESI, Michele, **107**
MARCHESI, Lodovica, **113**
MARCIAS, Gabriele, **27**
MASTINU, Mariano, **141**
MASURI, Sebastiano, **9**
MEREU, Monica, **47**
MESSANA, Gaspare, **49**
MONNI, Noemi, **11**
MORONI, Lorenzo, **197**
MULLIRI, Alice, **165**
MUZZETTO, Piera, **167**
NIEDDU, Francesco, **229**
ORRÙ, Roberto, **199**
PAL, Rajesh, **129**
PALA, Mauro, **221**
PALMAS, Vanessa, **131**
PASQUINI, Viviana, **217**
PELIZZON, Lucrezia, **153**
PELLIGRA, Vittorio, **175**
PERRA, Matteo, **29**
PES, Federica, **115**
PICCIAU, Emmanuele, **169**
PINNA, Andrea, **207**
PINTOR, Claudia, **61**
PINTOR, Maura, **85**
PIRINO, Paolo, **99**
PITZALIS, Luca, **117**
PONTILLO, Tiziana, **221**
PORCU, Michele, **143**
PORRÀ, Alessandro, **51**
PUGGIONI, Giulia, **31**
RAKHIMZHANOVA, Anar, **63**
RAPETTI, Mariangela, **35**
RASHID, Aiman, **101**
REN, Junkai, **13**
RIU, Federico, **15**
ROSSI, Christian, **35**
RUGGERONE, Paolo, **159**
SALIMBENI, Alice, **65**
SANTONI, Michele, **145**
SATTA, Jessica, **171**
SCRUGLI, Matteo Antonio, **89**
SERGIOLI, Giuseppe, **147**
SEQUEIRA, Lisa, **219**
SOGOS, Giulio, **33**
SOLINAS, Antonio Vincenzo, **103**
SPADA, Martina, **133**
SPANO, Andrea, **155**
STANCIU, Maria Madalina, **119**
STEFANO, Enzo, **3**
TASCA, Cecilia, **35**
TOCCO, Davide, **17**
TONELLI, Roberto, **107**
TRAMONTANO, Enzo, **211**
TROGU, Daniele, **209**
URAS, Marco, **91**
URAS, Nicola, **121**
VARGIU., Monica, **67**
VAROLI, Matteo, **157**
VIRDIS, Irene, **105**
ZACCHEDDU, Marco, **173**
ZAMMARCHI, Gianpaolo, **189**

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This volume reports, in brief, the experience of the students enrolled in the XXXIV 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.

