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UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

**DOTTORATO DI RICERCA / PHD PROGRAM IN  
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING**

## **Activities and Publications Report**

# PhD Student: **Michele Delli Veneri**

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**Student ID: DR993895**

**PhD Cycle: XXXV**

**PhD Cycle Chairman: Prof. Stefano Russo**

**PhD program student's start date: 01/11/2019**

**PhD program student's end date: 30/11/2022**

**Supervisor: Prof. Vincenzo Moscato**

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**Co-supervisor: Prof. Giuseppe Longo**

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**PhD scholarship funding entity: EUSTEMA S.p.A**

## General information

Michele Delli Veneri received in year 2018 the Master Science degree in Physics from the University of Napoli Federico II. He attended a curriculum in Computer Science within the PhD program in Information Technology and Electrical Engineering. He received a grant from Eustema S.p.A.

## Study activities

### Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1 <sup>st</sup>	Hardware and Software Infrastructures for Big Data	MSc course	12	Prof. Antonio Picariello	University of Naples Federico II
1 <sup>st</sup>	Data Management and Computer Networks	MSc course	12	Prof. Flora Amato	University of Naples Federico II
1 <sup>st</sup>	Start Cup Campania 2020 - Innovation management, entrepreneurship and intellectual property	Ad hoc course	5	Prof. Pierluigi Rippa	University of Naples Federico II
1 <sup>st</sup>	Design and Implementation of Augmented Reality Software Systems	Ad hoc course	4	Prof. Fasolino, Prof. Amalfitano	University of Naples Federico II
1 <sup>st</sup>	Machine Learning	MSc course	4	Prof. Aiello, Prof. Corazza, Prof. Sansone	University of Naples Federico II
1 <sup>st</sup>	Strategic Orientation for STEM Research & Writing	Ad hoc course	3.6	Prof. Fraser	University of Naples Federico II
2 <sup>nd</sup>	Information Theory	MSc course	6	Prof. Tulino	University of Naples Federico II
2 <sup>nd</sup>	Elaborazione dei Segnali Digitali	MSc course	6	Prof. Tulino	University of Naples Federico II
2 <sup>nd</sup>	ALMA I-TRAIN with the European ARC Network	External course	0.4	European ARC Network	European ARC Network

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### Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
2 <sup>nd</sup>	Matlab fundamentals	Online	2	20/02/20 - 27/03/20	University of Naples Federico II

### Attended Seminars

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Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1 <sup>st</sup>	Intelligenza Artificiale ed Etica: La ricerca IA alla prova delle sfide etiche	1.4	Prof. Roberto Prevete	University of Naples Federico II	ITEE
1 <sup>st</sup>	Computational Biology: large scale data analysis to understand the molecular basis of human diseases	0.2	Prof. Michele Ceccarelli	University of Naples Federico II	ITEE
1 <sup>st</sup>	How to get published with IEEE	0.4	Dr. Eszter Lukacs	IEEE Client Services Manager	ITEE
1 <sup>st</sup>	Large scale training of Deep Neural Networks	0.4	Dr. Giuseppe Fiameni	NVIDIA AI Technology Center Italy	Italian Association for Computer Vision, Pattern Recognition and Machine Learning (CVPL)
1 <sup>st</sup>	Bias from the Wild	0.4	Prof. Nello Cristianini	University of Bristol	CVPL
1 <sup>st</sup>	Space Signal Processing and Computational image formation	0.4	Saiprasad Ravishankar	Michigan State University	CVPL
1 <sup>st</sup>	Linear regression in PyTorch and Convolutional Neural Networks	0.4	Dr. Giuseppe Fiameni	NVIDIA AI Technology Center Italy	CVPL
1 <sup>st</sup>	Efficient Data Loading using DALI and Mixed Precision Training in Apex	0.3	Dr. Giuseppe Fiameni	NVIDIA AI Technology Center Italy	CVPL
1 <sup>st</sup>	Multi-GPU Training using Horovod, Deploying Models with TensorRT and Profiling with NVTX	0.4	Dr. Giuseppe Fiameni	NVIDIA AI Technology Center Italy	CVPL
1 <sup>st</sup>	Wearable Brain-Computer Interface for Augmented Reality-based Robotic Applications in Industry 4.0	0.2	Prof. Pasquale Arpaia	University of Naples Federico II	ITEE
1 <sup>st</sup>	Algorithmic accountability. Affidabilità e responsabilità negli algoritmi.	0.4	Antonio Sassano	Fondazione Bordini	ITEE

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1 <sup>st</sup>	IBM Quantum: I primi computer quantistici per la ricerca e la didattica	0.3	Prof. Federico Mattei	University of Parma	ITEE
2 <sup>nd</sup>	Picariello Lectures on Data Science, Performing an Iso27001 Assessment	0.2	Ing Enrico Micillo	Cybersecurity & Digital Protection Practice	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Connecting the dots: investigating an APT campaign using Splunk	0.2	Ing. Antonio Forzieri	EMEA	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Digital Project Management: practices, processes, techniques, tools and scientific approach	0.2	Prof. Dario Carotenuto	University of Naples Federico II	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, #andratuttobene: images, texts, emojis & geodata in a Sentiment Analysis pipeline	0.3	Prof. Serena Pelosi	University of Salerno	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, At the Nexus of Big Data, Machine Intelligence and Human Cognition	0.2	Prof. George S. Djorgovski	CALTECH	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Exploiting Deep Learning and Probabilistic Modelling for Behaviour Analytics	0.2	Prof. Giuseppe Manco	ICAR-CNR	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Data Driven Transformation in WINDTRE through Managers voice	0.4	Marcello Savarese	WINDTRE	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, From Photometric Redshifts to improved weather forecasting an interdisciplinary view on machine learning	0.2	Prof. Kai Polsterer	University of Haideberg	University of Naples Federico II

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2 <sup>nd</sup>	Picariello Lectures on Data Science, Cybercrime and electronic evidence, the international legal framework for an effective criminal justice response	0.2	Matteo Lucchetti	C-PROC	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, AI LEGAL: artificial intelligence from notary's sector - a case study	0.2	Salvatore Palange	Fuel Innovation for Business	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, The era of industry 4.0: new frontiers in business model innovation	0.2	Marco Bolzano	University of Naples Federico II	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Machine Learning: causality lost in translation	0.3	Prof. Edwin E Valentijn	University of Groningen	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Approaches to graph machine learning	0.2	Miroslav Cepek	Oracle Labs	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Visual interaction and communication in data science	0.4	Marco Quartulli	Vicomtech	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Big Data and computational linguistics	0.4	Francesco Cotugno	University of Naples Federico II	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Sensoria Health	0.2	Stefano Rossetti	University of Naples Federico II	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, the coming revolution of data driven discovery	0.3	Prof. Giuseppe Longo	University of Naples Federico II	University of Naples Federico II
2 <sup>nd</sup>	Picariello Lectures on Data Science, Distributional Semantics Methods: How Linguistic features can improve the semantic representation	0.4	Alessandro Mais	University of Salerno	University of Naples Federico II
2 <sup>nd</sup>	DoveAndiamoDomani -	0.3	Francesco Matteucci	Deep Tech	University of Naples Federico II

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2 <sup>nd</sup>	Artificial Intelligence and 5G combined with holographic technology: a new perspective for remote health monitoring	0.4	Dr. Pietro Ferraro, Dr. Pasquale Mammo lo	Telco	University of Naples Federico II
2 <sup>nd</sup>	From Cells to Galaxies, Introductory remarks: from cells to galaxies imaging challenges in Astronomy and Medicine	0.4	Neb Duric	University of Rochester Medical School	The National Radio Astronomy Observatory
2 <sup>nd</sup>	SAE 2021 - Big4small	0.4	Edwin Valentijn, Kai Posterer	University of Groningen	University of Rome La Sapienza
2 <sup>nd</sup>	Thriving as a doctoral student in informatics	0.4	Prof. Geraldine Fitzpatrick	TU Wien	Informatics Europe
2 <sup>nd</sup>	Adventures in Astronomical Time Series Analysis	0.4	Jeffrey D. Scargle	NASA Ames Research Center	IAA-IAU
2 <sup>nd</sup>	From Cells to Galaxies, Introduction to Radio Astronomy for Medical Imaging Professionals" and "Introduction to Medical Imaging for Radio Astronomers	0.4	Urvashi Räu, Daniel Sodickson	NRAO	The National Radio Astronomy Observatory
3 <sup>rd</sup>	Single Cell omits leverage Machine Learning to dissect tumor microenvironment and cancer immuno editing	0.4	Dr. Raoul J. P. Bonnie	Worcester University	DIETI
3 <sup>rd</sup>	From Cells to Galaxies, Inverse Imaging Techniques from Radio Imaging Side, Machine Learning For Medical Image Reconstruction	0.6	Dr. Voronkov, Dr. Ravishankar	NRAO	The National Radio Astronomy Observatory

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3 <sup>rd</sup>	Information field theory, from astronomical imaging to artificial intelligence	0.4	Torsten Enßlin	Max Plank Institute for Astrophysics	IAU-IAA
3 <sup>rd</sup>	From Cells to Galaxies, Challenges and Innovations in Visualisation of Radio Astronomy Data, Visualisation from the Medical Imaging Side	0.3	Dr. Taylor, Mr. Mather	NRAO	IAU-IAA
3 <sup>rd</sup>	The learning landscape in deep neural networks and its exploitation by learning algorithms	0.2	Riccardo Zecchina	Bocconi University	ITEE
3 <sup>rd</sup>	Methods for scalable probabilistic inference	0.2	Dan Foreman-Mackey	Flatiron Institute's Center for Computational Astrophysics	IAU-IAA
3 <sup>rd</sup>	From Cells to Galaxies, Software Systems used in Radio Astronomy, Enabling Mathematical Insights in Large-scale, N-Dimensional images using open-source toolkits	0.3	Kumar Golan, Beatriz Paniagua	NRAO	The National Radio Astronomy Observatory
3 <sup>rd</sup>	Picariello Lectures on Data Science II, Can a Text-To-Speech Engine generate human sentiments?	0.2	Prof. Vijay K. Gurbani	Computer Science Department, Illinois Institute of Technology	University of Naples Federico II
3 <sup>rd</sup>	From Cells to Galaxies, Identifying Areas of Collaboration; Next steps for a face to face meeting	0.2	Karen Praire	The National Radio Astronomy Observatory	The National Radio Astronomy Observatory
3 <sup>rd</sup>	Picariello Lectures on Data Science II, Towards a Political Philosophy of AI	0.4	Prof. Mark Coeckelbergh	University of Wien	University of Naples Federico II
3 <sup>rd</sup>	An Introduction to Deep Learning for Natural Language Processing	0.2	Dr. Marco Valentino	University of Manchester	ITEE
3 <sup>rd</sup>	Explainable Natural Language Inference	0.3	Dr. Marco Valentino	University of Manchester	ITEE



3 <sup>rd</sup>	Deep Learning based imaging in radio interferometry	0.2	Kevin Schimidt	TU Dortmund	IAU-IAA
3 <sup>rd</sup>	The Anomaly Detection Classifier for AlerCE broker	0.2	Manuel Perez Carrasho	UDEC/MAS	IAU-IAA
3 <sup>rd</sup>	A general purpose statistical method for improved learning under covariate shift	0.2	Roberto Trotta	University of Naples Federico II	University of Naples Federico II
3 <sup>rd</sup>	Conditional Invertible Neural Network (cINN) as an emission-line diagnostic tool for HII regions	0.2	Dr. Eun Kang	Heidelberg University	IAU-IAA

### Research activities

Michele Delli Veneri participated in the following research activities:

- In collaboration with Eustema S.p.A., I have studied and investigated the main approaches in literature for hybrid classification. State of the art methods in literature share common shortcomings: i) they are based on clustering algorithms which make assumption about the underling data distribution; ii) they separate clustering and classification in two separate phases; iii) they do not consider the effect of noise. To solve all three main shortcomings, I have developed HyCASTLE (a Hybrid Classification System based on Typicality, Labels and Entropy), a hybrid model based on the Typicality, with uses cluster aggregation/separation strategy based on both data topology and known labels. The work resulted in a publication on Knowledge Based Systems;
- In collaboration with the department of Geology, I have worked on the application of Deep Learning for the classification of earth drainage systems from satellite images. The work resulted in a publication on Nature Scientific Reports;
- In collaboration with the department of Dermatology, I have worked on the prediction of the outcomes of the Dupilumab treatments in elderly patients. The work resulted in a publication on the American Journal of Clinical Dermatology;
- In collaboration with INAF astronomers, I have worked on a method for defining rejection criteria for Euclid Probability Density Functions. The work resulted in a publication on MNRAS.

### Tutoring and supplementary teaching activities

Data Mining MOD .B (U2642) for the Data Science Master Degree, Prof. G. Longo. Between May and July 2021 I helped Prof. Longo with 16 hours of frontal lesson and student tutoring, and for another 24 hours between July and November.

### Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1 <sup>st</sup>	42.6	5.2	35	
2 <sup>nd</sup>	12.4	7.4	45	1.6
3 <sup>rd</sup>	0	4.5	60	

### Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
2 <sup>st</sup>	University of Groningen, Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence	Michael Biehl	13/09/2021 - 01/04/2022	Research on the SKA Source Detection and Characterisation Problem
3 <sup>st</sup>	ESO, Garching, Germany	Fabrizia Guglielmetti	15/05/2022 - 11/06/2022	Research on the the ALMA Source Detection and Characterisation Problem

### PhD Thesis

Current and forthcoming Astronomical observatories are rapidly increasing the quantity, velocity and complexity of their data products pushing Astronomy in the Big Data regime. Extracting scientifically usable data from such instruments involves the resolution of ill-posed inverse problems traditionally solved with algorithms which cannot cope anymore with the rising complexity. In the last decade, Machine Learning has seen a deep rise in its use both within and outside Astronomy. In this Thesis, I have developed a set of Deep Learning (DL) based pipelines aimed at the resolution of two such problems: the Radio Interferometric Deconvolution, Source Detection and Characterisation problem for two different radio interferometers, the Atacama Large Millimeter/submillimeter Array (ALMA) and the Square Kilometer Array (SKA), and the TOLIMAN space telescope Astrometric Signal Detection problem. Given the novelty of the instruments and the need for controlled experiments for the development and comparison of solutions, all studies carried out in this Thesis use simulated data. SKA and TOLIMAN data were acquired through my participation in the SKA Data Challenge 2 and COIN TOLIMAN Focus, while I developed a simulation

framework able to generate the needed ALMA observations by leveraging parallel computing. The ALMA pipeline is composed of six DL models: a Convolutional Autoencoder (CAE) for source detection within the spatial domain of the integrated data cubes, a Recurrent Neural Network (RNN) for denoising and peak detection within the frequency domain, and four Residual Neural Networks (ResNets) for source characterisation. The detection performances of the pipeline were compared to those of other state-of-the-art methods within the field and significant improvements in performances and computational times are achieved. Source morphologies are detected with subpixel accuracies obtaining mean residual errors of  $10^{-3}$  pixel (0.1 mas) and  $10^{-1}$  mJy/beam on positions and flux estimations, respectively. A direct comparison with tCLEAN, the current image deconvolution method employed by CASA, the ALMA data reduction pipeline, is made on the simplified mock data achieving a substantial improvement in reconstruction quality and speed.

The SKA pipeline, which I developed to address the shortcomings of the baseline pipeline developed during the Challenge in collaboration with COIN, is based on a combination of a classical Compressed Sensing algorithm, my 3D implementation of the Multi Vision Model, with six DL models: A 3D CAE for source detection, a 3D ResNet classifier to detect and remove false detections, and four 3D ResNet regressors to predict sources morphological parameters. The performances of the debugged, re-trained and optimised baseline pipeline and the revised pipeline are compared with those of the other solutions to the challenge. The revised pipeline reaches the highest score with slight improvements over the challenge winners.

The TOLIMAN pipeline is the only unsupervised pipeline developed in this Thesis and it is based on a CAE tasked with compressing the TOLIMAN image time series into a monodimensional latent space which is then analysed through a Lomb-Scargle periodogram in search of periodic components. The pipeline performances in detecting increasingly small and realistic Astrometric signals embedded within a series of simulated TOLIMAN observations of Alpha Cen star system are compared to those other sparsity-based state-of-the-art solutions within the field. The signals are simulated as time-dependent shifts in the positions of two overlapping point spread functions in the TOLIMAN images. Our pipeline is the only one which can reliably detect the signal with an amplitude of  $10^{-6}$  times the pixel size. The simulations contained only Poisson noise, in future works, all the more realistic sources of noise and systematic effects present in the real-world satellites will be injected into the simulations. Our pipeline is the only one which can reliably detect the signal with an amplitude of  $10^{-6}$  times the pixel size. The simulations contained only Poisson noise, in future works, all the more realistic sources of noise and systematic effects present in the real-world satellites will be injected into the simulations.

## Publications

Research results appear in 7 papers published in international journals, 0 papers published in national journals, 2 contributions to international conferences, 0 contributions to national conferences, 0 patents.

### List of scientific publications

#### International journal papers

**M. Delli Veneri**, L. Desdoigts, M. A. Schmitz, A. Krone-Martins, E. E. O. Ishida, P. Tuthill, R. S. De Souza, R. Scalzo, M. Brescia, G. Longo, A. Picariello,  
Periodic Astrometric Signal Recovery Through Convolutional Autoencoders,  
Intelligent Astrophysics, pp 167 - 195, part of the Emergence, Complexity and Computation book series,  
DOI: 10.1007/978-3-030-65867-0\_8

**M. Delli Veneri**, S. Cavuoti, R. Abbruzzese, M. Brescia, G. Sperli', V. Moscato, G. Longo,  
HyCASTLE: A Hybrid Classification System based on Typicality, Labels and Entropy,  
Knowledge-Based Systems, Volume 244, May 2022, DOI: 10.1016/j.knosys.2022.108566

**M. Delli Veneri**, L. Tychoniec, F. Guglielmetti, G. Longo, E. Villard,  
3D Detection and characterisation of ALMA sources through Deep Learning,  
Monthly Notices of the Royal Astronomical Society, Accepted on 12/11/2022,  
DOI: 10.1093/mnras/stac3314

**M. Delli Veneri**, R. S. De Souza, A. Krone-MARTins, E. E. O. Ishida, M. L. L. Dantas, N. Kennamer, COIN  
Collaboration,  
How have astronomers cited other fields in the last decade?,  
Research Notes of the American Astronomical Society, Volume 6, Number 6,  
DOI: 10.3847/2515-5172/ac74c7

V. Amaro, S. Cavuoti, M. Brescia, G. Riccio, C. Tortora, M. D'Addona, **M. Delli Veneri**, N. R. Napolitano, M.  
Radovich, G. Longo,  
Rejection criteria based on outliers in the KiDS photometric redshifts and PDF distributions derived by  
Machine Learning,  
Intelligent Astrophysics pp 245 - 265, part of the Emergence, Complexity and Computation book series,  
DOI: 10.1007/978-3-030-65867-0\_11

C. Donaddio, M. Brescia, A. Riccardo, G. Angora, **M. Delli Veneri**, G. Riccio,  
A novel approach to the classification of terrestrial drainage networks based on deep learning and  
preliminary results on solar system bodies,  
Scientific Reports 11, Nature, a.n. 5875, 2021,  
DOI: 10.1038/s41598-021-85254-x

C. Patruno, G. Fabbrocini, G. Longo, G. Argenziano, S. M. Ferrucci, L. Stringendi, K. Peris, M. Ortoncelli, A. Offidani, G. F. Amoruso, M. Talamonti, G. Girolomoni, T. Grieco, M. Iannone, E. Nettis, C. Foti, F. Rongioletti, M. Corazza, **M. Delli Veneri**, M. Napolitano, DADE Study Group,  
Effective and safety of long-term dupilumab treatment in elderly patients with atopic dermatitis: a multicenter real-life observational study,  
American Journal of Clinical Dermatology, 22, 481 - 586, 2021  
DOI: 10.1007/s40257-021-00597-5

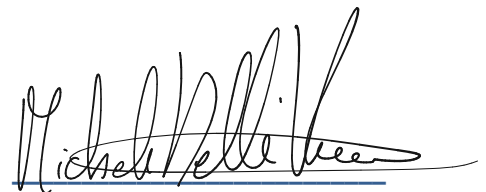
### International conference papers

F. Guglielmetti, P. Arras, **M. Delli Veneri**, T. Enßlin, G. Longo, L. Tychoniec, E. Villard,  
Bayesian and Machine Learning Methods in the Big Data era for astronomical imaging,  
*International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering, IHP, Paris, July 18-22, 2022,*  
DOI: <https://arxiv.org/abs/2210.01444v1>

**M. Delli Veneri**, L. Tychoniec, F. Guglielmetti, E. Villard, G. Longo,  
3D Detection of ALMA Sources through Deep Learning,  
New Frontiers in Mining Complex Patterns, 2022, ECML-PKDD Conference, Grenoble, France, 19 - 23-09-2022,  
DOI: <http://www.di.uniba.it/~mignone/NFMCP/#Submit>

Date 19/11/2022

PhD student signature



Supervisor signature

