Emanuele **Ballarin**

PH.D. STUDENT IN DEEP LEARNING @ AILAB, UNIVERSITY OF TRIESTE, ITALY

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2nd year Ph.D. student in Deep Learning (within the Applied Data Science and Artificial Intelligence doctoral programme) among the AILab, Department of Mathematics, Informatics, and Geoscience, University of Trieste, Italy.

Broadly interested in neurobiologically-inspired and Bayesian deep learning, adversarial robustness of machine learning systems, unsupervised learning, generative modelling, computational neuroscience, and methodological cross-fertilisation of artificial intelligence research with natural and neural sciences.
Strong believer in reproducible, open science (and *source*).

Education

University of Trieste   *Trieste, Italy*

PH.D. IN APPLIED DATA SCIENCE AND ARTIFICIAL INTELLIGENCE   *Nov. 2022 - Present*

Research activity in the areas of *neuro-inspired* and *adversarially-robust deep learning*.

Supervisor: Prof. Luca Bortolussi. Collaborating with Prof. Fabio Anselmi, Dott. Alex Rodriguez, and Dott. Alessio Ansuini.

Currently:
- Development of unsupervised approaches – inspired by neurocognitive mechanisms – for the improvement of adversarial robustness in deep neural image classifiers;
- Development of unsupervised, geometrically-motivated strategies for effective and interpretable dimensionality reduction;
- Study of the emergence of landmark properties of biological neural networks within artificial neural networks trained by first-order stochastic optimisation methods.

University of Trieste   *Trieste, Italy*

M.SC. IN DATA SCIENCE AND SCIENTIFIC COMPUTING (ARTIFICIAL INTELLIGENCE & MACHINE LEARNING TRACK)   *Oct. 2019 - Nov. 2022*

Elective curriculum choice focused on theoretical foundations of deep learning, machine learning, artificial intelligence, data science.

Final mark: 110/110 *cum laude*.
Research thesis title: CARSO: *Counter-Adversarial Recall of Synthetic Observations. A novel deep learning architecture and methodology for the improvement of adversarial robustness in image classification tasks, inspired by image recollection during visual learning.*
Supervisors: Prof. Luca Bortolussi, Dott. Alessio Ansuini.

University of Trieste   *Trieste, Italy*

B.SC. IN PHYSICS   *Sep. 2014 - Apr. 2020*

Elective curriculum choice focused on statistical data analysis, machine learning and computational methods, experimental physics.

Research thesis title: *Generative models of adversarially-robust artificial neural models. A preliminary feasibility study.*
Supervisors: Prof. Luca Bortolussi, Prof. Fabio Benatti.

Academic Experience

University of Trieste   *Trieste, Italy*

TEACHING ASSISTANT FOR THE DEEP LEARNING M.SC. COURSE   *Mar. 2024 - Present*

Teaching assistant / tutor for the joint DSAI, SDIC, and DSSC *Deep Learning* M.Sc. course, dedicated to *state of the art* deep learning and differentiable programming methods for supervised, unsupervised and self-supervised learning. In charge of laboratory sessions and support to didactic activity.

Lecturer: Dott. Alessio Ansuini

University of Trieste
Teaching assistant for the Probabilistic Machine Learning M.Sc. course

Trieste, Italy

Mar. 2023 - Jul. 2023

Teaching assistant / tutor for DSSC *Probabilistic Machine Learning* M.Sc. course, dedicated to advanced machine learning techniques, with a focus on Bayesian methods. In charge of laboratory sessions and support to didactic activity.

Lecturer: Prof. Luca Bortolussi

University of Trieste
Intern | Volunteer research assistant among the AILab (was AI-CPS @ UniTS)

Trieste, Italy

(discontinuously) Nov. 2018 - Oct. 2022

Carried out concept-proofing, prototyping, software development and maintenance, and research support activities – both as part of academic internships and as a volunteer – in the areas of *safe and trustworthy*, and *neurosymbolic* artificial intelligence.

Specifically:
- Use of kernel methods for the learning, and dimensionality reduction, of embeddings of *Signal Temporal Logic* formulae – and the learning of their satisfiability on dynamical systems trajectories;
- Use of inverse reinforcement learning and hybrid logic/statistical methodologies to mine logical properties of human-generated trajectories, and steer the learning and control of artificial agents towards compatibility with human laws, conventions and/or expectations.

Supervisor: Prof. Luca Bortolussi

University of Trieste
Intern among the CMS Group, INFN LC Trieste

Trieste, Italy

Mar. 2018 - May 2018

Statistical data analysis of 7 TeV proton-proton collision calorimetry data produced by CMS ECAL at LHC, using the *tag-and-probe* method.

Supervisors: Prof. Giuseppe Della Ricca, Dott. Fabio Cossutti

Work Experience

Kyiv International Contract Fair
Intern in the IT and the Building and Infrastructure departments

Kyiv, Ukraine

Jul. 2013

Internship awarded on the basis of a competitive admission procedure. Performed exploratory data analysis, administration of MySQL databases, and translation (En-It) of technical documentation and public-oriented information material.

Schools and Workshops

EEML
Eastern European Machine Learning Summer School (EEML 2023)

Košice, Slovakia

Jul. 2023

International summer school – co-organised by Google DeepMind, ESET, the Faculty of Electrical Engineering and Informatics of the Technical University of Košice, and AIslovakIA – comprising lectures, hands-on tutorials, roundtables, and poster sessions. The speaker lineup included top, world-class researchers, leaders, and business actors. Selected to present a poster about own research work Carso.

SISSA
TEX2023: Efficient coding and processing for perception and action

Trieste, Italy

Jul. 2023

Interdisciplinary workshop with leading international speakers, dedicated to efficient coding and processing in the context of perception and action.

ICTP
Youth in High-Dimensions

Trieste, Italy

May/Jun. 2023

Interdisciplinary workshop with international leading speakers and participants, dedicated to recent developments in the areas of high-dimensional statistics, machine learning, statistical inference, computational neuroscience, statistical physics, and complex systems. Selected to present a poster about own research work Carso.

SISSA
Machine Learning, Statistical Physics and Neuroscience Workshop

Trieste, Italy

Jun. 2022

Interdisciplinary workshop with leading international speakers, dedicated to recent developments at the interface of statistical physics, neuroscience, cognitive science, and artificial intelligence.

EESTEC LC Trieste
2ND EESTEC Summer School: Smart Mobile City

Trieste, Italy

Jul. 2013

European summer school – co-organised by EESTEC and the University of Trieste – dedicated to open data for digital urban development, mobile software development and design.

Scuola Normale Superiore di Pisa *San Miniato, Italy*

80ᵀᴴ Corso per l'Orientamento Universitario *Jun. 2013*

National summer school organised by Scuola Normale Superiore di Pisa, on the basis of a competitive selection procedure. Multidisciplinary university-level classes were offered by renowned academics and industrial speakers.

Technical Skills

- Knowledge of Python, R, C++, Fortran, Wolfram Language (Mathematica), Bash, LaTeX;
- Knowledge of the NumFocus numerics, data science and machine learning software ecosystem (e.g., NumPy, SciPy, Pandas, Scikit-Learn);
- Knowledge of differentiable programming and deep learning frameworks: PyTorch (including internals) and JAX;
- Knowledge of Windows and GNU/Linux-based operating systems, both as desktop and server systems. Experience in using and managing multi-architecture and GPU-accelerated systems;
- Working knowledge and use of HPC systems and cloud-based deployments for computational science and deep learning workloads;
- Contribution to – and maintenance of – open-source software projects, including *ML/DL*-related.

Linguistic Skills

- <u>Italian</u>: Native proficiency (mother-tongue);
- <u>English</u>: Full professional proficiency in written and oral communication; experience with technical writing of software documentation. Owner of CEFR-C1 certification.
- <u>French</u>: Conversational proficiency (approx. CEFR-B2; 7 years of curricular study).

Outreach activities

SDIA FEST: Festival of Data Science and Artificial Intelligence *Monfalcone, Italy*

High School "Michelangelo Buonarroti" *Apr. 2024*

Outreach festival for high school students and the general public, co-organised by *Liceo "Michelangelo Buonarroti"* and *Fondazione Cassa di Risparmio di Gorizia*. In charge (with colleagues) of the student-targeted hands-on workshop *"First Steps in Generative Artificial Intelligence"*.

Introduction to Data Science and Machine Learning *Trieste, Italy*

Scientific High School "Galileo Galilei" *Feb. 2024*

Pilot outreach programme for 4ᵗʰ-year high school students, organised by the University of Trieste. In charge of the final lecture of the course: *"From the Linear Model to Deep (Artificial) Neural Networks"*.

Volunteering

AI2S – Artificial Intelligence Student Society, O.d.V. *Trieste, Italy*

Member of the Directive Committee *(as an ord. member) Jun. 2020 - Present*

Volunteering organisation dedicated to academic and general-public outreach in the field of Artificial Intelligence, support and complement to university teaching activities. The association operates mainly in the Trieste area.

Publications and Preprints

CARSO: Blending Adversarial Training and Purification Improves Adversarial Robustness *preprint (arXiv:2306.06081)*

EB, Alessio Ansuini, Luca Bortolussi *Oct. 2023*

Emergent representations in networks trained with the Forward-Forward algorithm *preprint (arXiv:2305.18353)*

Niccolò Tosato, Lorenzo Basile, **EB**, Giuseppe de Alteriis, Alberto Cazzaniga, Alessio Ansuini *May 2023*