

Carlo Baldassi

Curriculum vitae

CONTACT INFORMATION Bocconi University
Department of Decision Sciences via Roentgen 1
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RESEARCH INTERESTS In general: **distributed optimization algorithms, discrete optimization problems, machine learning**, inference problems (reconstruction of interaction networks from network activity), Statistical Physics of disordered systems.
More specifically, applications of Statistical Physics and development of distributed algorithms for biological problems and biological data analysis, and for the design of novel machine learning algorithms, in particular in the fields of:
Neural Networks (theoretical study of the fundamental properties of learning with neural networks, and the exploitation of such properties for the design of new algorithms and the improvement of existing ones; reconstruction problems, neural data analysis);
Genomics (inference of protein structures and properties from the statistical analysis of large datasets; analysis of interaction networks)

ACADEMIC EXPERIENCE *Assistant Professor* **February, 2017 - Present day**
Bocconi University BIDSa, Milan, Italy

Visiting Researcher **October, 2016 - December, 2016**
Microsoft Research New England, Cambridge, Massachusetts, U.S.A.

Assistant Professor (Italian: RTDa) **March, 2016 - January, 2017**
Politecnico di Torino DISAT, Torino, Italy
HuGeF - Human Genetics Foundation, Torino, Italy

Visiting Researcher **August, 2015 - December, 2015**
Microsoft Research New England, Cambridge, Massachusetts, U.S.A.

PostDoctoral researcher **May, 2011 - March, 2016**
Politecnico di Torino DISAT, Torino, Italy
CMP center for multidisciplinary research on optimization and inference, Torino, Italy
HuGeF - Human Genetics Foundation, Torino, Italy

PostDoctoral researcher **Jan, 2009 - May, 2011**
Politecnico di Torino DIFIS, Torino, Italy
CMP center for multidisciplinary research on optimization and inference, Torino, Italy

PostDoctoral researcher **Jan, 2008 - Dec, 2008**
I.S.I. Foundation, Torino, Italy

EDUCATION

PENS Neuroscience School, Arcachon, France

Advanced Course in Computational Neuroscience August-September 2006

- Dissertation Topic: “Spatio-temporal spiking pattern learning by IF neurons with binary synapses”

Università degli Studi di Torino, Torino, Italy

I.S.I. Foundation, Torino, Italy

Ph.D. Program in “Complex Systems in Post-genomic Biology”, December 2007

- multi-disciplinary Ph.D. Program in Theoretical Physics, Computer Science and Biology
- Dissertation Topic: “A novel algorithm for supervised learning in neuronal models with binary synapses”
- Advisors:
 - prof. Nicolas Brunel
 - prof. Riccardo Zecchina

Università degli Studi di Trieste, Trieste, Italy

Master’s degree in Theoretical Physics, September 2004,

- Dissertation Topic: “Estensioni del formalismo SP per problemi di K-soddisfacibilità al caso di variabili multistato” (“*Extensions of the SP formalism for K-satisfiability problems to the case of multi-state variables*”)
- Advisors:
 - prof. Marco Budinich
 - prof. Riccardo Zecchina
- Final mark: 110/110 magna cum laude

Liceo Scientifico G. Marinelli, Udine, Italy

Maturità scientifica (B.A.), July 1997

- Experimental course with enhanced program in scientific subjects and foreign languages
- Final mark: 60/60

PUBLICATIONS - JOURNAL ARTICLES

C. Baldassi, C. Lauditi, E. M. Malatesta, G. Perugini and R. Zecchina, Unveiling the structure of wide flat minima in neural networks *submitted for publication*, 2021, arXiv:2107.01163

C. Baldassi, E. M. Malatesta, M. Negri and R. Zecchina, Wide flat minima and optimal generalization in classifying high-dimensional Gaussian mixtures *J. Stat. Mech. Theor. Exp.*, Dec 2020, 124012, DOI:10.1088/1742-5468/abcd31

C. Baldassi, R. Della Vecchia, C. Lucibello and R. Zecchina, Clustering of solutions in the symmetric binary perceptron, *J. Stat. Mech. Theor. Exp.*, Jul 2020, 073303, DOI:10.1088/1742-5468/ab99be

C. Baldassi, F. Pittorino and R. Zecchina, Shaping the learning landscape in neural networks around wide flat minima, *Proc. Natl. Acad. Sci. U.S.A.*, 2020 117 (1) 161-170, DOI:10.1073/pnas.1908636117

C. Baldassi, S. Cerreia-Vioglio, F. Maccheroni and M. Marinacci, A behavioral characterization of the Drift-Diffusion Model and its multi-alternative extension to choice under time

pressure, *Management Science* 66 (11), 5075-5093, 2020, DOI:10.1287/mnsc.2019.3475

C. Baldassi, E. M. Malatesta and R. Zecchina, Properties of the geometry of solutions and capacity of multi-layer neural networks with rectified linear unit activations, *Phys. Rev. Lett.*, 2019, 123: 170602, DOI:10.1103/PhysRevLett.123.170602

C. Baldassi, Recombinator-k-means: A population based algorithm that exploits k-means++ for recombination, *submitted for publication*, 2019, arXiv:1905.00531

L. Saglietti, F. Gerace, A. Ingrosso, C. Baldassi and R. Zecchina, From statistical inference to a differential learning rule for stochastic neural networks, *Interface focus* 8(6):20180033, DOI:10.1098/rsfs.2018.0033

C. Baldassi, F. Gerace, H.J. Kappen, C. Lucibello, L. Saglietti, E. Tartaglione and R. Zecchina, Role of synaptic stochasticity in training low-precision neural networks, *Phys. Rev. Lett.*, 2018, 120(26): 268103, DOI:10.1103/PhysRevLett.120.268103

C. Baldassi and R. Zecchina, Efficiency of quantum vs. classical annealing in nonconvex learning problems, *Proc. Natl. Acad. Sci. U.S.A.*, Feb 2018, 115(7):1457-1462, DOI:10.1073/pnas.1711456115

C. Baldassi, F. Gerace, L. Saglietti and R. Zecchina, From inverse problems to learning: a statistical mechanics approach, *Journal of Physics: Conference Series*, Jan 2018, 955(1):012001, DOI:10.1088/1742-6596/955/1/012001

C. Baldassi, A method to reduce the rejection rate in Monte Carlo Markov Chains on Ising spin models, *J. Stat. Mech. Theor. Exp.*, Mar 2017, 033301, DOI:10.1088/1742-5468/aa5335

C. Bosia, F. Sgrò, L. Conti, C. Baldassi, F. Cavallo, F. Di Cunto, E. Turco, A. Pagnani and R. Zecchina, RNAs competing for microRNAs mutually influence their fluctuations in a highly non-linear microRNA-dependent manner in single cells, *Genome Biol.*, Feb 2017; 18(1):37, DOI:10.1186/s13059-017-1162-x

C. Baldassi, C. Borgs, J. Chayes, A. Ingrosso, C. Lucibello, L. Saglietti and R. Zecchina, Unreasonable Effectiveness of Learning Neural Nets: Accessible States and Robust Ensembles, *Proc. Natl. Acad. Sci. U.S.A.*, Nov 2016; 113(48):E7655-E7662, DOI:10.1073/pnas.1608103113

T. Gueudré, C. Baldassi, M. Zamparo, M. Weigt and A. Pagnani, Simultaneous identification of specifically interacting paralogs and interprotein contacts by direct coupling analysis, *Proc. Natl. Acad. Sci. U.S.A.*, Oct 2016; 113(43):12186-12191, DOI:10.1073/pnas.1607570113

C. Baldassi, F. Gerace, C. Lucibello, L. Saglietti and R. Zecchina, Learning may need only a few bits of synaptic precision, *Phys. Rev. E*, May 2016, 93 (5), 052313, DOI:10.1103/PhysRevE.93.052313

C. Baldassi, A. Ingrosso, C. Lucibello, L. Saglietti and R. Zecchina, Local entropy as a measure for sampling solutions in Constraint Satisfaction Problems, *J. Stat. Mech. Theor. Exp.*, Feb 2016, 023301, DOI:10.1088/1742-5468/2016/02/023301

C. Baldassi, A. Ingrosso, C. Lucibello, L. Saglietti and R. Zecchina, Subdominant Dense

Clusters Allow for Simple Learning and High Computational Performance in Neural Networks with Discrete Synapses, *Phys. Rev. Lett.*, 2015, 115 (12), DOI:10.1103/PhysRevLett.115.128101

A. Alemi-Neissi, C. Baldassi, N. Brunel and R. Zecchina, A three-threshold learning rule approaches the maximal capacity of recurrent neural networks, *PLoS Comput. Biol.*, 2015, 11 (8), e1004439, DOI:10.1371/journal.pcbi.1004439

C. Baldassi and A. Braunstein, A Max-Sum Algorithm for Training Discrete Neural Networks, *J. Stat. Mech. Theor. Exp.*, 2015, P08008, DOI:10.1088/1742-5468/2015/08/P08008

C. Baldassi, M. Zamparo, C. Feinauer, A. Procaccini, R. Zecchina, M. Weigt and A. Pagnani, Fast and accurate multivariate Gaussian modeling of protein families: Predicting residue contacts and protein-interaction partners, *PLOS ONE*, 2014, 9 (3), e92721, DOI:10.1371/journal.pone.0092721

C. Baldassi, A. Braunstein and R. Zecchina, Theory and protocols for the material tempotron model, *J. Stat. Mech. Theor. Exp.*, 2013 (12), P12013, DOI:10.1088/1742-5468/2013/12/P12013

C. Baldassi, A. Alemi-Neissi, M. Pagan, J. DiCarlo, R. Zecchina and D. Zoccolan, Shape Similarity, Better than Semantic Membership, Accounts for the Structure of Visual Object Representations in a Population of Monkey Inferotemporal Neurons, *PLoS Comput. Biol.*, 2013, 9(8): e1003167, DOI:10.1371/journal.pcbi.1003167

C. Baldassi, Generalization Learning in a Perceptron with Binary Synapses, *J. Stat. Phys.*, Volume 135, Number 5 / September, 2009, pp. 902-916, DOI:10.1007/s10955-009-9822-1

C. Baldassi, A. Braunstein, N. Brunel and R. Zecchina, Efficient supervised learning in networks with binary synapses, *Proc. Natl. Acad. Sci. U.S.A.*, 2007 Jun 26; 104(26):11079-11084, DOI:10.1073/pnas.0700324104

PUBLICATIONS -
BOOK CHAPTERS

T. Gueudré, C. Baldassi, A. Pagnani and Martin Weigt, Predicting Interacting Protein Pairs by Coevolutionary Paralog Matching, in *Protein-Protein Interaction Networks*, Methods in Molecular Biology, Volume 2074, 2020, pp 57-65, Springer, ISBN:978-1-4939-9873-9, DOI:10.1007/978-1-4939-9873-9_5

C. Baldassi, A. Braunstein, A. Ramezanpour and R. Zecchina, Statistical Physics and Network Optimization Problems, in *Mathematical Foundations of Complex Networked Information Systems*, Lecture Notes in Mathematics, Volume 2141, 2015, pp 27-49, Springer, ISBN:978-3-319-16966-8, DOI:10.1007/978-3-319-16967-5_2

J. Secco, A. Vinassa, V. Pontrandolfo, C. Baldassi and F. Corinto, Binary Synapse Circuitry for High Efficiency Learning Algorithm Using Generalized Boundary Condition Memristor Models, in *Advances in Neural Networks: Computational and Theoretical Issues*, Smart Innovation, Systems and Technologies, Volume 37, 2015, pp 369374, Springer, ISBN:978-3-319-18163-9, DOI:10.1007/978-3-319-18164-6_36

PUBLICATIONS -
CONFERENCE
PRESENTATIONS
AND PROCEEDINGS

C. Baldassi, On robust minima in neural networks: theoretical analyses and algorithmic strategies, invited oral presentation at *Artificial Intelligence 2021 - Spring Session*, Gran Sasso Science Institute, Italy, 2021

C. Baldassi, Wide flat minima and entropi algorithms, invited oral presentation at "Quantum

and *Physics based machine learning (QPhML) 2020*, ELLIS, Milan-Tübingen-Nijmegen, 2020

F. Pittorino, C. Lucibello, C. Feinauer, E. M. Malatesta, G. Perugini, C. Baldassi, M. Negri, E. Demyanenko and R. Zecchina, Entropic gradient descent algorithms and wide flat minima, *International Conference on Learning Representations (ICLR)*, 2021, arXiv:2006.07897

C. Baldassi, On the existence of wide flat minima in neural network landscapes: analytic and algorithmic approaches, invited oral presentation at *Workshop IV: Using Physical Insights for Machine Learning*, IPAM, University of California, Los Angeles, 2019

C. Baldassi, A large deviations statistical physics approach to finding wide flat minima in neural networks landscapes, invited oral presentation at *Statistical physics and neural computation international workshop*, Guang-zhou, China, 2019

C. Baldassi, Exploiting quantum fluctuations for robust and efficient neural network training, invited oral presentation at *DALI/ELLIS: Quantum ML workshop*, San Sebastian, Spain, 2019

C. Baldassi, A theoretical framework to link local entropy, cross-entropy, wide states and generalization in neural networks, invited oral presentation at *XXIV Convegno Nazionale di Fisica Statistica e dei Sistemi Complessi*, Parma, Italy, 2019

C. Baldassi, Julia: a programming language for data science, invited oral presentation at *4th Open SmartData@PoliTO Workshop*, Torino, Italy, 2019

C. Baldassi, Robust accessible states allow efficient training of neural networks with very low precision stochastic synapses, invited oral presentation at *Computation by natural systems*, The Royal Society at Chicheley Hall, UK, 2018

C. Baldassi, Synaptic [classical and quantum] fluctuations as a recipe for robust and efficient neural network training, invited oral presentation at *2nd Physics Informed Machine Learning conference*, Santa Fe, NM, USA, 2018

P. Chaudhari, C. Baldassi, R. Zecchina, S. Soatto, A. Talwalkar and A. Oberman, Parle: parallelizing stochastic gradient descent, *SysML*, 2018, arXiv:1707.00424

P. Chaudhari, A. Choromanska, S. Soatto, Y. LeCun, C. Baldassi, C. Borgs, J. Chayes, L. Sagun, R. Zecchina, Entropy-SGD: Biasing gradient descent into wide valleys, *International Conference on Learning Representations (ICLR)*, Toulon, France, 2017, arXiv:1611.01838

C. Baldassi, Neural networks optimization and dense states, invited oral presentation at *XXII Convegno Nazionale di Fisica Statistica e dei Sistemi Complessi*, Parma, Italy, 2017

C. Baldassi, F. Gerace, A. Ingrosso, C. Lucibello, L. Saglietti and R. Zecchina, Robust accessible states allow efficient training of neural networks with very low precision synapses, oral presentation at *StatPhys26*, Lyon, France, 2016.

A. Alemi-Neissi, C. Baldassi, N. Brunel and R. Zecchina A purely local, distributed, simple learning scheme achieves near-optimal capacity in recurrent neural networks without explicit supervision, *Biological Distributed Algorithms (BDA) 2015*, MIT, Boston MA, USA

A. Alemi-Neissi, C. Baldassi, N. Brunel and R. Zecchina, Input-driven unsupervised learning in recurrent neural networks, *Cosyne Abstracts*, Salt Lake City USA. 2014: 191

A. Gitter, A. Braunstein, A. Pagnani, C. Baldassi, C. Borgs, J. Chayes, R. Zecchina and E. Fraenkel, Sharing information to reconstruct patient-specific pathways in heterogeneous diseases, *Pacific Symposium on Biocomputing*, 2014 (19), 39-50, DOI:10.1142/9789814583220_0005

A. Alemi-Neissi, C. Baldassi, A. Braunstein, A. Pagnani, R. Zecchina and D. Zoccolan Information theoretic and machine learning approaches to quantify non-linear visual feature interaction underlying visual object recognition *BMC Neuroscience 2012*, 13(Suppl 1):P2 (16 July 2012), DOI:10.1186/1471-2202-13-S1-P2

M. Pagan, A. Alemi-Neissi, C. Baldassi, R. Zecchina, J. DiCarlo and D. Zoccolan, From luminance to semantics: how natural objects are represented in monkey inferotemporal cortex, *COSYNE 2011 proceedings*, P1 (24 February 2011)

C. Baldassi, A. Braunstein, N. Brunel and R. Zecchina, Adding a weak, stochastic, non-specific reinforcement process to the clipped perceptron algorithm lets it efficiently solve the supervised learning problem in neuronal models with binary synapses, oral presentation at the *Minischool and Workshop on Multiple Time Scales in the Dynamics of the Nervous System*, ICTP Trieste, IT, 2008

C. Baldassi, A. Braunstein, N. Brunel and R. Zecchina, Efficient supervised learning in networks with binary synapses, oral presentation at CNS*2007 Toronto, CA, *BCM Neuroscience 2007*, 8(Suppl 2):S13, DOI:10.1186/1471-2202-8-S2-S13

COMPUTER SKILLS I'm a major contributor in the development of the Julia programming language for technical and scientific computing. I maintain several registered Julia packages, and I'm the creator and maintainer of the julia-vim plugin. I teach the Julia language in a PhD program on Computer Science and Statistics.

I teach several undergraduate courses on Python and its numerical and scientific library stack (numpy/scipy).

I have excellent experience in the use of C and C++ programming languages, Wolfram Research's Mathematica, Mathworks' Matlab and Unix shell scripting languages for scientific applications, and in the use of Linux and Microsoft Server clusters for performing large parallelized computations.

FOREIGN LANGUAGES English (fluent), French (good)