Stefano Crotti

PhD in statistical physics

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Profile and interests

I am a physicist with a strong mathematical background and an interdisciplinary education in modelling of complex systems, probabilistic methods and scientific computing. I am able to run and evaluate small to medium scale computational projects, independently or in a team, and communicate findings in English, tuning the exposition to the composition of the audience.

I am interested in mathematical and computational challenges, best if driven by virtuous goals.

Skills

Probabilistic modelling and algorithms

- Background in calculus, linear algebra, probability and statistics
- Theoretical understanding of probabilistic inference and statistical learning, from linear regression to deep neural networks and Bayesian methods
- Monte Carlo simulations (MCMC, Hamiltonian MC, Gillespie, Gibbs sampling), Molecular Dynamics
- Dynamic Programming, Graph theory, Optimization, Linear Programming
- Graphical models, message-passing, tensor network algorithms

Scientific computing

- Data structures, Automatic Differentiation (Forward and Reverse mode, adjoint methods)
- Object-oriented programming, type systems, awareness of time and memory performances
- Signal processing and information theory: data compression, error correction
- Ability to write flexible, readable and documented code in Julia, MATLAB, Python
- Develop and maintain Julia packages
- Python: pandas, PyTorch, fastAI
- Software: git, GitHub, Unix CLI, VSCode

Languages

- Italian (mother tongue), English (proficient), French (fluent), Spanish (intermediate)

Projects

Stochastic dynamics on networks (paper inference ↗, paper steady state ↗, code ↗, blog post ↗)   2022-

- Considered a wide class of Markov processes that can model: epidemic spreading, biological processes, social dynamics, glassy behavior
- Some tasks are computationally prohibitive: calculating marginals, performing inference on a partially observed process, computing observables at steady state
- Developed an approximation method based on the belief propagation algorithm and tensor network techniques

Closest vector problem and lossy data compression (paper ↗, code ↗)   2020-2022

- Three equivalent problems: lossy compression with random source, ferromagnetic p-spin ground state, closest vector problem

- Used methods from statistical physics to characterize the compression capabilities of codes based on sparse graphs

Classification of peripheral nerve signals (homepage ↗, paper ↗)   2019-2021
- Processing and analysis of real-world mammal peripheral nerve signals
- Development of a neural-network based classifier
- Presented at the 10th International IEEE/EMBS Conference on Neural Engineering (NER), May 2021

Education

PhD   **Polytechnic University of Turin (Italy)**, Physics   2021-2025
- Supervisor prof. Alfredo Braunstein
- Statistical physics-inspired approximation methods for high-dimensional probability distributions
- PhD thesis ↗: *The cavity method for in and out of equilibrium stochastic processes on graphs*

MsC   **Polytechnic University of Milan (Italy)**, Mathematical Engineering   2021
- Double degree in the context of Alta Scuola Politecnica ↗, a two-year honor program on entrepreneurship and innovation

MSc   **Polytechnic University of Turin (Italy)**, Physics of Complex Systems   2018-2020
- Statistical physics, modelling of biological systems, algorithms and computation
- Master thesis: *Lossy compression and other hard optimization problems: a statistical physics approach*
- 1 semester exchange @ KU Leuven, Beligum

BSc   **Polytechnic University of Turin (Italy)**, Electronic Engineering   2015-2018
- 1 semester exchange @ INP Grenoble, France

Additional Experience

Academic visits
- Center for Complex Systems, Physics Faculty, Havana University, Cuba (Feb-Mar 2024)
- Institute for Theoretical Physics, Chinese Academy of Sciences, Beijing, China (Jun-Jul 2024)

Seminars and presentations
Conditioned stochastic processes: from random walks to epidemic reconstruction
- Data science division, Bain&Co, Milan, Italy (Feb 2024)

Teaching
- Problem sessions for the course "Algorithms for Optimization, Inference and Learning", prof. Alfredo Braunstein, academic years 2022/23, 2023/24
- A three-part mini-course ↗ on "Algorithmic tools for Statistical Mechanics".

Open source software

I am the author and maintainer of a few small Julia packages including:
- BeliefPropagation.jl ↗: a flexible and efficient implementation of the Belief Propagation algorithm
- IndexedGraphs.jl ↗: a graph library with efficient access to edge properties, based on sparse matrices
- TensorTrains.jl ↗: a lightweight package to work with the simplest type of Tensor Networks