ELIOT AYACHE, Ph.D.

MATHEMATICAL MODELER / DATA SCIENTIST

NATIONALITY: FRENCH (EU CITIZEN)

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SUMMARY

I am an experienced modeler with a background in astrophysics, harnessing complex algorithms, data and statistics, for applications in research and innovation. I have an executive engineering degree, and 5 years of professional experience in machine learning, data analysis and numerical simulation. I have lead research projects and built, tested and deployed software for "end to end" modelisation and analysis. I thrive in both specialised and interdisciplinary collaborative environments and have strong communication skills with both specialists and non-experts. I am always fascinated with any type of challenging mathematical problem and I find that the tools I have learnt and developed in astrophysics can be applied to nearly every quantitative field.

PROFESSIONAL EXPERIENCE

Research Scientist — Sept. 2021 - …
STOCKHOLM UNIVERSITY (SWEDEN)

- Analysis of scientific literature: built a Natural Language Processing pipeline using publicly available transformer models on a dataset of over 74,000 abstracts.

- Data visualization: Identified sub-structure in a previously unified class of 1200 time-series using UMAP for unsupervised learning. http://batumapp.herokuapp.com/

- Research project leader: Numerical hydrodynamics simulations of relativistic jets.
  o Devised the research project, carrying out over 40 HPC numerical simulations (250,000 cpu.hours). Built data post-processing and visualization pipelines.
  o Developed solutions for code stability for problematic input parameter values. Reached 100% successful runs.

- Implemented a Fortran implicit PDE solver module as a feature upgrade to an existing Monte-Carlo radiative transfer simulation code. Improved accuracy by 10%.

- Led and published a machine learning conference paper on variational autoencoders applied to time-series.

- Organized weekly seminars delivered by international guest speakers over the course of 6 months.

Research Scientist — Oct. 2017 – Aug. 2021
UNIVERSITY OF BATH (UK)

- Developed from scratch a specialized massively parallel moving-mesh finite-volume relativistic hydrodynamics code in C++. Improved efficiency by a factor 10, and accuracy by 100%, over legacy codes. Public release and maintenance of the code.

- Carried out unsupervised clustering of astrophysical sparse time-series data using variational deep embedding and recurrent neural networks on a dataset of 1500 samples. 3rd place poster prize, London Mathematical Society symposium 2020.

- 2 first-author publications in a top-level scientific journal.

- Organized, chaired and presented at international conferences sessions on machine learning.

- Supervised 5 Bachelor and Masters theses. Teaching (computational astrophysics, programming…) and outreach (~120h).

SKILLS

ML Algorithms
Data Visualization
Statistical Modeling
Clustering & Classification
Numerical modeling
Simulations
Model Development
High-performance computing

Analytical thinking
Problem solving
Project management
Public speaking
Technical writing
Teaching
Collaboration
Communication

TECHNICAL EXPERTISE

Languages: Python (expert), C/C++ (expert), Fortran, SQL, Bash, Java, HTML5/CSS.

Packages and services: Scikit-Learn, Tensorflow, PyTorch, Numpy, Pandas, Plotly/Dash, OpenMP, MPI, HDF5, Git…

Mathematical methods: Neural networks, self-supervised / unsupervised learning, Bayesians statistics (MCMC), Gaussian processes, PDEs, Monte-Carlo.

LANGUAGES

- French: Native
- English: Fluent C2 (TOEFL iBT 112/120)
- Spanish: Intermediate B1
- Swedish: Beginner A2

OTHER PROJECTS

Numerical Simulation Research Intern
OBSERVATOIRE DE PARIS (FRANCE)

Mar-jun 2017

- Implemented a radiation module into a legacy numerical hydrodynamics code in Fortran, to numerically integrate spatially resolved radiative flux from relativistic jets.
- Carried out and post-processed 16 HPC simulations to investigated the nature of magneto-hydrodynamical instabilities.

Data Analysis and Modelisation Research Intern
OBSERVATOIRE DE GENÈVE (SWITZERLAND)

May-Aug 2016

- Bayesian analysis of improvement in accuracy from observations with 6 upcoming spectrographs on exoplanet internal structure inference using MCMC.
- Devised follow-up observation strategy for a simulated sample of 1700 exoplanets to maximize information gain with minimal telescope operation time.

Data Analysis Research Intern
NASA JET PROPULSION LABORATORY (USA)

Jun-Sept 2015

- Designed an original method to reject X-ray detected galaxy cluster candidates using the radial distribution of their member galaxies in infrared telescope observation images.
- Combined heterogenous data from 3 different catalogues, and fitted the procedure on a dataset of 249 confirmed galaxy clusters.
- Formulated and incorporated innovative solutions to identify and reject cluster members using photometric redshift.

Deep Learning Research Intern
OBSERVATOIRE DE PARIS (FRANCE)

Part-time - Sept-Feb 2014

- Created a dataset of 16,300 simulated images of galaxies from a dataset of 51,524 labelled legacy images.
- Used a state-of-the-art CNN deep learning model for automatic classification of galaxies in future observations.
- Built image data-augmentation pipelines to reduce over-fitting.

EDUCATION

Ph.D., Computational Astrophysics
UNIVERSITY OF BATH (UK)

2017 – 2021

High performance computing for scientific calculus and numerical simulations.

M.Sc., Astronomy, Astrophysics, Space Engineering
OBSERVATOIRE DE PARIS, PSL RESEARCH UNIVERSITY (FRANCE)

2015 – 2017

First of two years carried out in parallel with the last year of Mines ParisTech.
Relevant classes: data analysis, signal/image processing (building of a radio-telescope array imaging pipeline), numerical methods, Earth dynamics.

Diplôme d'ingénieur (equiv M.Sc. Executive Engineering)
MINES PARISTECH, PSL RESEARCH UNIVERSITY (FRANCE)

2013 – 2016

Top 2 French scientific "Grande Ecole" (National Graduate Engineering School).
Applied mathematics and physics geared towards applications in the private sector.
Minor: Earth Science. Relevant classes: geo-statistics, signal processing, cost assessment and modelling.

Preparatory classes, Physics and Chemistry
LYCÉE SAINT-LOUIS, PARIS (FRANCE)

2011 – 2013

Two-year intensive undergraduate program in mathematics, physics and chemistry.
Ranked 79th / 3489 (National "Grandes Écoles" admission competitive exam).