Cosmo Santoni
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Applied mathematics researcher with expertise in statistical analysis, machine learning, and deep learning for complex systems modelling. Proficient in Python, R, and Julia, with a proven track record of applying advanced methods to inform national and international policy, including UK COVID-19 response and Global Fund malaria strategies.

PROFESSIONAL EXPERIENCE

Malaria Technical Analyst – *Machine Learning & Complex Systems, Imperial College London, U.K., 2023* –
- Delivered neural surrogate models (GRU/LSTM in PyTorch) that reduced runtime from 96 h HPC to 90 s on a single consumer GPU (≈3,840×) while matching in-house agent-based model *malariasimulation* (R^2 = 0.998 for prevalence), enabling real-time what-if analysis.
- Built an end-to-end ML pipeline (LHS generation → HPC batch sims → DuckDB/HDF5 data layer → training/eval → CLI & APIs) with AMP/CUDA and Optuna; reproducible, versioned artifacts and automated reports.
- Developed case-incidence estimators (XGBoost/Random Forest with Tweedie + long-tail weighting) achieving RMSE = 0.265, R^2 = 0.926 and R^2 = 0.941 on the top-5% high-incidence slice.
- Open-sourced MINTverse (segMINT, estiMINT, MINTe, MINTer): modular data/ML stack that standardises ingest → estimate → emulate and cuts time-to-insight from hours to seconds.
- Partnered with the Global Fund and World Health Organization to translate model outputs into deployment guidance for novel mosquito nets, linking ML metrics to program decisions.
- Scale: ~65k scenarios × 8 runs → ~524k simulations; 4,380 daily records × 12 metrics → ~2.3B rows (~28B values), all SQL-queryable in seconds; deterministic via checksums, cached models, versioned artifacts.

Research Software Engineer – *Pathogen Epidemiology Review Group, Imperial College London, UK., 2024* –
- Developed and executed software lifecycle management strategies to enhance code quality, maintainability, and efficiency. Led the integration of DevOps practices and quality-of-life features, such as virtual environments, CMD-checks, test-coverage targets, and package managers, to ensure consistent development and version compatibility. Presented project outcomes to multiple organizations, including Médecins Sans Frontières, World Health Organization, Public Health Canada, and data.org.
- Conducted lectures and workshops on programming principles, emphasising code management, test writing, and I/O validation to boost team expertise.
- Established team standards for open-source software practices, overseeing the review and management of pull requests and issues, focusing on bug fixes, performance enhancements, and alignment with research objectives.

Research Scientist – *Machine Learning, German Centre for Artificial Intelligence (DFKI), Germany, 2022 – 2023*
- Led pioneering cross-disciplinary research utilising advanced Deep Neural Networks, including the development of Deep Neural Universal Differential Equations, to model and predict complex phenomena such as tumour growth, enhancing decision-making in healthcare contexts.
- Adapted the developed predictive frameworks for broader societal applications, including predicting criminal behaviour and the spread of gun violence, demonstrating the versatility and societal relevance of advanced AI tools.
- Integrated robust AI ethics and interpretability principles into model design and deployment, ensuring transparency, safety, and fairness in AI-driven healthcare and public safety applications.

Research Assistant – *COVID-19 Real Time Modelling, Imperial College London, U.K., 2021 – 2023*
- Achieved the "SPI-M-O Award for Modelling and Data Support" on behalf of SAGE, presented by the UK Government's Chief Scientific and Medical Officers. Managed the development and testing of our open-source packages (OSS) and led daily and weekly development efforts, ensuring consistency of statistical approaches across our projects and OSS packages.
- Developed weekly comprehensive reports used by UK Government SPI-M-O & SAGE, providing essential statistical support to the UK government's crisis response during the pandemic.
- Collaborated with Prof. Neil Ferguson to lead the creation and development of deterministic and stochastic models and data pipelines for infectious disease transmission during the COVID-19 crisis, primarily using traditional and particle Markov Chain Monte Carlo (MCMC) methods for Bayesian inference.

TECHNICAL SKILLS & LANGUAGES
- **Languages:** Python, R, Julia, C++, C#, SQL, Bash (Linux)
- ***ML / DL:*** *PyTorch, TensorFlow/Keras,* **XGBoost**, **Optuna**, *NumPy, Pandas*
- ***Data & Storage:*** *DuckDB, HDF5*
- ***HPC & Acceleration:*** *CUDA, Automatic Mixed Precision (AMP); CPU/GPU clusters*
- ***Tooling:*** *Git/GitHub, CI/CD (GitHub Actions), Linux*

EDUCATION

- **PhD in Applied Mathematics,** *Imperial College London, U.K., January 2025 – December 2027*
  Thesis: "*Large-Scale Acceleration of Real-Time Agent-Based System Simulations with Neural Surrogates and Graph Neural Networks"***

- **MSc. Epidemiology (Merit),** *Imperial College London, U.K., 2020 – 2021*

- **BSc. (Hons.) Mathematics with Economics (2:1),** *Aston University, U.K., 2015 – 2019*

PUBLICATIONS & REFERENCES

Publications:

- *Morgenstern, C., et al. (including Cosmo Santoni) "Severe acute respiratory syndrome (SARS) mathematical models and disease parameters: a systematic review and meta-analysis"* **The Lancet Microbe***, DOI: https://doi.org/10.1101/2024.08.13.24311934*
- *Imai, N., Rawson, T., et al. (including Cosmo Santoni.) "Quantifying the impact of delaying the second COVID-19 vaccine dose in England: a mathematical modelling study"* **The Lancet Public Health***, DOI: https://doi.org/10.1016/S2468-2667(22)00337-1*
- *Perez-Guzman, P. N., Knock, E., et al. (including Cosmo Santoni.) "Epidemiological drivers of transmissibility and severity of SARS-CoV-2 in England."* **Nature Communications***, DOI: https://doi.org/10.1038/s41467-023-39661-5*

Manuscripts under Review:
- *McCabe, R., et al. (including Cosmo Santoni) "The impact of ambiguously reported epidemiological parameters for infectious disease modelling and recommended best practices"* **The Lancet Infectious Disease**
- *Cosmo Santoni., et al. "Deep Neural Universal Differential Equations: A Novel Approach for Tumour Volume Growth in Complex Mathematical Systems"* **Nature Machine Intelligence**

Published Software & Tools:
- *MINTverse: A modular Python/R toolkit—DuckDB data layer + PyTorch emulators + XGBoost/ranger—for real-time prevalence/case forecasting. Open-source. Production ready.*
- *Epireview: A tool to obtain the latest data, figures and tables from the Pathogen Epidemiology Review Group (PERG). PERG is an internationally recognised World Health Organization collaborative collective.*
- *Sircovid: Tools for Bayesian analysis of stochastic models using adaptive Metropolis-Hastings and particle MCMC.*
- *Spimalot: The models in this package can be used to estimate key epidemic parameters and predict the course of the epidemic under different intervention scenarios.*
- *MCState: Parameter inference for stochastic, compartmental models from data, using Monte Carlo methods.*

CONFERENCES & PRESENTATIONS

- **Epireview: Hands-on Workshop for Public Health & Epidemiology Researchers,** *Infectious Disease Modelling Conference, Bangkok, Thailand, November 2024*
- **Applying Neural Network Emulation to Assess the Impact of Pyrethroid-Pyrrole Bed Nets on Malaria in Africa,** *9th International Conference on Infectious Disease Dynamics, Bologna, Italy, November 2023*
- **Investigating Parameterisation and Inference Trade-Offs in Stochastic and Deterministic Epidemic Models**, *9th International Conference on Infectious Disease Dynamics, Bologna, Italy, November 2023*

ACADEMIC SERVICE & VOLUNTARY WORK

- **Curator, Amphibian & Malaria Collections**, *Museum of Life Sciences, King's College London*, U.K., 2025 –
- **Departmental MRC GIDA Seminar Series Co-Organiser**, *Imperial College London, U.K.*, 2023 –
- **MSc. Epidemiology Graduate Teaching Assistant**, *Imperial College London, U.K.*, 2021 – 2022
- **Lay Grant Reviewer**, *University College London & Parkinson's UK*, U.K., 2019 – 2022
- **BSc. Mathematics Undergraduate Teaching Assistant**, *Aston University*, U.K., 2017 – 2019