

# Ra'ad Mahmoud PhD MPhys

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## Career Summary

Machine learning engineer with 4 yrs industry experience and a doctorate in Computational Astrophysics. I have worked on several ML projects from data synthesis to model construction and deployment. As an experienced Python developer of 10 years, I have a track record of valuable software contributions in a range of sectors, from producing world-class time-series models of black holes, to novel computer vision techniques now employed at a major automotive manufacturer, to detection of explosives in X-ray images for aviation security.

In my current role I lead the development of neural networks for the characterisation of pathogenic DNA to combat bio-terrorism.

## Software Development Skills

### Programming Languages.

**Python** Native language. 10 years experience on projects including physical modelling of magnetic dipoles, cosmic expansion, black hole accretion dynamics, and extensive ML. Proficient with many Python libraries, including SciPy, NumPy, Matplotlib, scikit-learn, OpenCV, PIL, pandas, SQLite, fastAPI and TensorFlow/keras (see "Deep Learning").

**Bash** Working proficiency. 8 years of working with Linux - primarily in Ubuntu - has led to good knowledge of shell scripting. I am comfortable with package/environment management tools such as conda, pip and venv.

**SQL** Working proficiency. 2 years experience, primarily via Python SQLite.

**C++** Moderate proficiency. 1 year experience, producing fast subroutines to model the energy and time-dependent behaviour of accretion physics. This fast code allowed direct model fitting of observational high-energy data for the first time, overcoming decades-long standing challenges for the field.

### Deep Learning & MLOps.

**Tensorflow & Keras** 5 years experience (1.5 yrs research + 3.5 yrs industry) building deep learning algorithms for inference in astronomy, the automotive industry, aviation security and bioinformatics. I have a good understanding of the mathematical basis underlying many types of neural networks - in particular convolutional networks and the object detection family - and how to construct customised networks, loss functions and robust data-sets using OOP.

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- Data Production** At Kromek I am responsible for data generation pipelines for object detection (explosive ID), and for sequence characterisation (genomic analysis). This has involved designing and writing pipelines which can generate simulated data from scratch, permit custom augmentations, record parameters of the dataset, and ensure complete reproducibility of large datasets ( $\sim 100$ s of GBs). I have experience in manual and automated annotation of data, having built tools for my team to web-scrape virology literature, and curate/clean the resultant labels.
- Cloud Computing & Restful APIs** Extensive experience with AWS (mainly EC2) for data generation, model development and deployment, building micro-service based architectures for a growing professional user-base. These micro-services have mainly employed fastAPI as their web framework
- CI/CD** Fluent in in app containerisation with Docker and deployment via uvicorn, DockerHub, GitHub actions to AWS EC2.
- VCS** Git & GitHub: 6 years of programming collaboratively has necessitated good Git habits. See contribution history at [GitHub](#).
- HPC** 3 years experience writing Python/C++ code for usage on high performance computing on COSMA5, a 6700-core Sandy Bridge system.

#### Other Technical.

#### Interpersonal Skills.

Extensive experience of presenting my work, having spoken at several international conferences in astrophysics and bioinformatics.

Well suited to output-oriented teamwork and collaboration, evidenced by past internships and prolific collaborations during PhD.

Good experience of mentoring in an industrial context at Kromek, where I have overseen and directed the technical work of a PhD intern and junior colleagues.

## Employment + Experience

- 2020–Present** **Deep Learning Engineer at Kromek Group Ltd.**, Thomas Wright Way, Sedgefield.
- 3 years** I am currently the technical lead of a small team of engineers developing neural networks to characterise short DNA and RNA reads. This project is funded by a key UK Government defence body, following on from a very successful precursor project which I also lead. At Kromek, I have also been the sole engineer on a set of proprietary neural nets which integrate computer vision and materials analysis for explosive detection in aviation security; these networks augment existing object-detection architectures with 3D and materials information to drastically improve threat detection rates for X-ray imaging.

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- 2019–2019 **AI Intern at Nissan Motor Manufacturing UK Ltd**, Washington Road, Sunderland.
- 2 months Industrial placement in the Deep Learning team at Nissan, Sunderland, developing methods for improved computer vision techniques. Involved heavy use of convolutional neural network (CNN) construction and optimisation, and advanced image processing techniques. The image optimization method I designed now plays a part in their automated defect detection system, with this system deployed at multiple manufacturing sites world-wide.
- 2017–2017 **Astronomy Intern at Japan Aerospace Exploration Agency**, Sagamiara Campus, Tokyo, Japan.
- 3 months Worked at JAXA, Sagamiara, networking with global contacts, contributing to cutting-edge X-ray research and providing Python detector calibration code now employed throughout the field.
- 2015–2015 **Intern at Superconductivity Group**, Durham University, Durham.
- 3 months Conducted research into the mechanical properties of superconducting solder alloys for use in the next generation of fusion tokamaks to follow the \$14 billion ITER (International Thermonuclear Experimental Reactor) in Cadarache, France.

## Education

- 2016–2020 **PhD in Computational Astrophysics**, *Centre for Extragalactic Astronomy*, Durham University, (*Funded by STFC.*)
- Thesis title: *Spectral-Timing Models of the Central Engine in Accreting Black Holes*
- Awards:
- Elsevier book prize for outstanding 1st year postgraduate student [pool of 30; £100].
- 2012–2016 **MPhys in Physics and Astronomy**, *Department of Physics*, Durham University, *1st Class, Highest degree mark in year* .
- Dissertation Title: *A Monte Carlo Approach to Habitability in the Milky Way*
- Awards:
- Vice-Chancellor's academic excellence award 2013/14 [£2000].
  - Level 3 computational physics prize 2015 [pool of 200; £100].
  - J A Chalmers prize 2016 for highest overall degree mark (83%) [pool of 200; £100].
- 2005–2012 **'A2': Mathematics (A\*), Physics (A), Chemistry (A).**
- 'AS': Further Mathematics (A)**
- Monks Walk Comprehensive School

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## Publications

**"Origins of the UV/X-ray Relation in Arakelian 120"**, R. Mahmoud, C. Done, D. Porquet, A. Lobban, 2023, *MNRAS*, 521(3), 3586.

**"Discarding the disc in a changing state AGN: the UV/X-ray relation in NGC 4151"**, R. Mahmoud, C. Done, 2020, *MNRAS*, 491(4), 5126.

**"Reverberation Reveals the Truncated Disc in the Hard State of GX 339-4"**, R. Mahmoud, C. Done, B. De Marco, 2019, *MNRAS*, 486(2), 2137.

**"A Physical Model for the Spectral-Timing Properties of Black Holes"**, R. Mahmoud, C. Done, 2018, *MNRAS*, 480(3), 4040.

**"Modelling the Energy Dependence of Black Hole Binaries"**, R. Mahmoud, C. Done, 2018, *MNRAS*, 473(2), 11.

**"Superconducting and Mechanical Properties of Low-Temperature Solders for Joints"**, Y. Tsui, R. Mahmoud, E. Surrey and D. Hampshire, 2016, *IEEE Trans. Appl. Supercond.*, 23 (3).

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