IRA J. S. SHOKAR

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PROFILE

PhD Candidate at the University of Cambridge's Department of Applied Mathematics and Theoretical Physics and Centre for Doctoral Training in the Application of Artificial Intelligence for Environmental Risk, researching emulation of atmospheric fluid flows and stochastically driven systems using probabilistic deep learning.

Research Interests: Probabilistic Deep Learning, Generative Models, Fluid Dynamics, Geophysical Fluid Dynamics, Turbulence, Chaotic Systems, Stochastic PDEs, Reduced Order Models.

EDUCATION

Pembroke College, University of Cambridge Oct 2021 – Present
PhD Applied Mathematics - Application of Artificial Intelligence.
Topic: Deep learning to develop reduced-order-models of chaotic and stochastically forced fluids to enable insight into the underlying dynamics and extreme events.
Co-Supervised by Professors Peter Haynes & Rich Kerswell at DAMTP.

Pembroke College, University of Cambridge Oct 2020 – Sep 2021
MRes Physical Natural Sciences - Environmental Data Science - Merit (70%+).
Thesis: 'Deep learning to predict dynamics on an inertial manifold of mid-latitude jet systems'.
Co-Supervised by Professors Peter Haynes & Rich Kerswell at DAMTP.

University College, University of London Sep 2017 – Jul 2020
BSc Physical Natural Sciences - Theoretical Physics - First Class Honours in all 3 years (70%+).
Thesis: 'Deep Learning Classifier Robustness for Neutrino Event Detection using Domain Adversarial Neural Networks'.
Supervised by Dr Chris Backhouse, formally of UCL.

Tiffin School - Secondary Education
4 A-Levels: **A*** in Mathematics and Further Mathematics; **A** in Economics and Physics.
6 AS-Levels: **A** in above, History and Physical Education. **10 GCSEs**: 6**A*** & 4**A** grades.

PUBLICATIONS

Journal Publications:

4. Shokar, I. J. S., Kerswell, R. R., and Haynes, P. H.: Stochastic Latent Transformer: Efficient modelling of stochastically forced zonal jets, (Under Review), arXiv preprint doi:10.48550/arXiv.2310.16741 (2023).

Presentations at Conferences and Workshops:

3. Shokar, I. J. S., Haynes, P. H., and Kerswell, R. R.: Reduced-Order Modelling of Stochastically Forced Zonal Jets using a 'Stochastic Latent Transformer', APS DFD 2023, Bulletin of the American Physical Society, Washington D.C., USA, meetings.aps.org/Meeting/DFD23/Session/T28.7 (2023).

2. Shokar, I. J. S., Haynes, P. H., and Kerswell, R. R.: Learning Stochastic Dynamics with Probabilistic Neural Networks to study Zonal Jets, EGU General Assembly 2023, Vienna, Austria, doi.org/10.5194/egusphere-egu23-9121 (2023).

1. Shokar, I. J. S., Haynes, P. H., and Kerswell, R. R.: Learning Stochastic Dynamics with Neural Networks to study Zonal Jets, UK Fluids Network Workshop on Data-Driven Methods in Fluid Dynamics, Leeds, UK, fluids.leeds.ac.uk/2023/workshop-data-driven-methods-in-fluid-dynamics (2023).

INVITED TALKS

Imperial College London, Magri Lab Seminar (December 2023) - 'Capturing stochastically forced PDEs using probabilistic deep learning'.

European Centre for Medium-Range Weather Forecasts, Machine Learning Seminar (November 2023) - 'Capturing extreme events in zonal jet dynamics using probabilistic deep learning'.

PRIZES AND AWARDS

UK Fluids Network Workshop on Data-Driven Methods in Fluid Dynamics - Best Presentation (2023)
- Talk title: 'Learning Stochastic Dynamics with Neural Networks to Study Zonal Jets' - slides.

Smith–Knight & Rayleigh–Knight Prizes - Essay Prize (2023)
- Annual prize for research by a graduate student in mathematics at the University of Cambridge.
- Title: 'Learning Stochastic Dynamics with Probabilistic Neural Networks to Study Zonal Jets' - essay.

UKRI EPSRC Scholarship - Master's & Doctoral Full Studentship (2020)
- Full funding for postgraduate study at the CDT in the Application of Artificial Intelligence for Environmental Risks.

UCL Data Science Society Hackathon - Winning Team (2019)
- Using American Express credit card customer datasets, we developed a product personalisation strategy using k-means clustering and a random forest model- trading off credit card growth and risk of defaults.

Arm Holdings, Applied Machine Learning Insight Challenge - Winning Team (2019)
- Applied an adaptive image filter to a webcam image using a CNN to produce portraits in the style of famous artists.

SELECT ACADEMIC RESEARCH EXPERIENCE

Modeling 3D Chaotic Dynamics with the Stochastic Latent Transformer. *Research Article (Ongoing Research).*
- Using the Stochastic Latent Transformer (linked below), we capture chaotic dynamics in an under-resolved multi-layer fluid flow.
- We examine the statistical equivalence between long-term emulations and numerical integrations and the model's efficacy in capturing spontaneous transition events exhibited by the system.

Generalising across regimes to assess extreme events. *Research Article (In Preparation).*
- This study employs the Stochastic Latent Transformer (linked below) pre-trained on a singular parameter regime, utilising fine-tuning on a significantly smaller dataset of a stochastically forced nonlinear partial differential equation (SPDE).
- Diverse phenomena emerge in different regimes, yet the Stochastic Latent Transformer adeptly captures the varied dynamics, even when interpolating to unseen regimes.
- The model is able to successfully capture the spontaneous transition events exhibited by the system across the parameter range.

Stochastic Latent Transformer, doi:10.48550/arXiv.2310.16741. *Research Article (Under review).*
- A deep learning method for producing reduced-order models of the time evolution of SPDEs. This approach is applied to model atmospheric zonal jets, where turbulent eddies are stochastically parameterised.
- The deep learning model achieves a five-order-of-magnitude speed-up compared to traditional numerical methods.
- Using the deep learning model we characterise the spontaneous transition events in the SPDE system.

Data-Driven Exploration of Mid-Latitude Weather. *MRes Thesis.*
- Developed an Autoencoder to explore whether a Beta-plane turbulence model of tropospheric mid-latitude circulation lay on an internal manifold, with the reduced form leading to a reconstruction error two orders of magnitude smaller than PCA.
- Explored the variability of the system due to its stochastic parameterisation scheme using a neural network to predict ensemble variation.

Assessing Temporal Change In The Exposure Of Informal Settlements Through Repeat Satellite Observation. *MRes Team Research Project.*
- Developed a settlement classifier with a change detection model to repeat satellite imagery, to identify the growth or contraction of informal settlements.
- Using this, we then quantify exposure to natural hazards with available socio-economic and historical disaster data.

Deep Learning Classifier Robustness for Neutrino Event Detection using Domain Adversarial Neural Networks. *BSc Thesis.*
- Developed an Adversarial Neural Network to improve the performance of a Convolutional Neural Network to classify neutrino interactions, for the analysis of neutrino oscillations, by training the model to be invariant to the differences in production mechanisms between the data sources: simulated data and the detector data.

Cellular Automata Model to Simulate Motorway Traffic Flow *Computational Physics Report.*
- Simulated motorway traffic flows to compare the similarities with granular flow when traffic shockwaves arise.

INDUSTRIAL RESEARCH EXPERIENCE

Data Science & Analytics Summer Intern Jul 2019 – Aug 2019
FTI Consulting *Aldersgate St, City of London*

- Conducted network analysis on the Panama Papers dataset for a bank's fraud due diligence using a `Neo4j` graph network in `Python`.
- Automated web scraping and querying using `Python` for large datasets.
- Used pattern identification such as fuzzy token matching and anomaly detection models to assist a client in fraud detection.

TEACHING EXPERIANCE

Deep Neural Networks - Part II Computer Science, University of Cambridge
- Example Classes (Lent Term 2022, 2023 & 2024).

Applied Machine Learning - AI4ER CDT, University of Cambridge
- Introduction Classes (Michaelmas Term 2022 & 2023).
- Resources can be found here

ORGANISED WORKSHOPS

Cambridge Centre for Climate Science - Machine Learning for Climate Science Workshop. (Mar 2022)
- Organised with 2 other graduate students a workshop introducing Machine Learning to researchers in the atmospheric sciences.
- Included with 3 interactive sessions & a hackathon implementing ML on in situ atmospheric data.
- In-person attendance reached capacity with 40 attendees, along with 8 virtual attendees.
- Resources can be found here.

SUMMER SCHOOLS

Institute of Computing for Climate Science, Cambridge (2023)
- Organisation Volunteer and speaker - talk title: 'Learning Zonal Jet Dynamics with Stochastic Latent Transformers'.

Institute of Computing for Climate Science, Cambridge (2022)
- Attendee.

SERVICE AND COMMITTEE POSITIONS

Pembroke College, University of Cambridge
- Library invigilator (Sep 2021 – Present).

Graduate Parlour, Pembroke College, University of Cambridge
- Housing Officer (May 2022 – Oct 2023).
- President (May 2021 – May 2022).
- Events Officer (Nov 2020 – May 2022).

Institute of Computing for Climate Science, Cambridge
- Summer School organisation volunteer (Jul 2023).

CDT in the Application of Artificial Intelligence for Environmental Risks
- Academic Representative (Sep 2021 – Aug 2022).

Lillian-Penson Hall, University of London
- Resident Advisor (Aug 2019 – Aug 2020).

Department of Physics & Astronomy, University College, University of London
- Undergraduate Academic Mentor (Sep 2018 – Dec 2018).

Junior Common Room, Nutford House, University of London
- Events Officer (Sep 2017 – Jun 2018).

TECHNICAL SKILLS

- *Languages*: `Python`, `Julia`, `MATLAB`, & `C++` ; `slurm` & `bash`; `HTML` & `CSS`.
- *Machine Learning Frameworks*: `PyTorch`, `TensorFlow` & `JAX`
- `Git` & LaTeX.