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Me: A Computational Statistics and Data Science PhD Student

- Currently in the second year of my PhD. I am located at the University of Bristol in the Compass CDT and my supervisor is Dr. Rihuan Ke.
- My work focuses on developing continual learning methods [2, 8] which try and reduce the problem of catastrophic forgetting [5, 7, 9] in neural networks when learning a series of tasks sequentially.
- This research area could have serious impacts on the ways you can train and deploy AI models and their capabilities once deployed. This includes models that are more data and computationally efficient, models that can learn while deployed and models that are better at preserving privacy.

🧙 Technical Skills

(My best) Tools	:	Python, Pytorch, MLX, R.
Deep-Learning	:	Can do the big and the small, eg. training large numbers of neural networks on vision tasks in parallel on super-computer clusters, eg. I wrote a neural network from scratch (including backprop!) in C++. I also work on theory, eg. I developed a novel meta-learning technique.
Statistics	:	Have wide breadth and depth including theory and implementation, especially when it comes to machine learning.
Other Maths	:	Probability theory, Optimization, Linear Algebra.
Other CS	:	Theory of computation, all the programming paradigms, bits of all the other important stuff (architecture, algorithms, etc.).
More Other	:	Know a fair bit of computational neuroscience. Some other tools I'm proficient in using are Git, Github, Bash, SLURM and lots of other bits and pieces.

🧑‍🎓 Education

Masters at University of Bristol — Bristol, UK
Joint Mathematics and Computer Science degree (MEng), graduated with first class honors. — *2018 –- 2022*

Canford School — Dorset, UK
A Maths, A* (D2 Pre-U) Spanish, A Further Maths, A Physics, A EPQ (On CNN's in autonomous cars).* — *2016 –- 2018*

Canford School — Dorset, UK
5 A's, 4 A's, B.* — *2014 –- 2016*

Projects

Latent Representations and Catastrophic Forgetting (CDT Mini-project) *Python, Pytorch, SLURM* Source Code

- Used the encoding portions of various networks to investigate the effect of latent representations on catastrophic forgetting [5, 7, 9] in a continual learning [2, 8] task.
- Used both frozen and trainable versions of the encoder to investigate the effect of fixed vs. flexible latent representations on catastrophic forgetting.
- Pretrained encoders using a mixture of classification and representation learning objectives to investigate their potential effect on catastrophic forgetting.
- Found immediate and complete forgetting in all networks bar the largest (Resnet18 and Resnet50) when the encoder was frozen, suggesting using frozen feature extractors could somewhat help mitigate catastrophic forgetting.
- Also theorised a new and very simple continual learning technique based on some of the experimental results.

Meta-Learning (Masters Dissertation) *Python, Numpy, Matplotlib, HIPS-autograd* Source Code

- Meta-learning [6] involves creating models able to "learn how best to learn", I investigated a particular subset of meta-learning which uses deep learning to infer a prior for the weights of a neural network.
- Using this prior as a starting point, it can then quickly learn new similar tasks using k-shot learning.
- Implemented the Model-Agnostic-Meta-Leaning (MAML) algorithm [4] with a fully connected network from scratch on a toy regression task.

- Showed improved performance and reduced computation compared to 'regular' deep learning.
- Augmented the MAML algorithm to work on temporal data.
- Created a novel extension of MAML called MATML which achieved better performance on temporal data.

Psychedelics and Vision (Bachelors Dissertation) *Python, Numpy, Matplotlib* Source Code

- Validated whether a field equation model for how visual hallucinations arise in the visual cortex [3] worked in a simulation of discrete spiking neurons.
- Simulated a spiking neural network of both excitatatory and inhibitory LIF neurons [1] using biologically plausible wiring from scratch.
- Created a tool for translating the activity from the simulated network into its corresponding retinal imagery.
- Found that increasing excitatory synapse strength lead to the appearence of hallucinatory patterns validating the claims of the field equation model.

Others... *Python, C++, SLURM, Github*

- **Slune**: A python package I've made for conducting blazing fast hyper-parameter tuning on SLURM powered computing clusters by taking advantage of the fact that it's embarrassingly parallel. Source Code
- **NeuralNetcpp**: A neural network I wrote from scratch in C++. I am also still working on this one. First larger project I've done with C++ so it is a little rough around the edges! Source Code
- **Open Source Contributions**: Have contributed to the Ivy framework.

Work

Teaching assistant roles (2023-Present): Helped run the labs for the machine learning unit and currently teaching the mathematical programming unit.

Responsible Innovation Facilitator (2023-Present): In this role I help run responsible innovation workshops where we train PhD students across disciplines how to engage in responsible and ethical research. As part of the role I also have to spend time reflecting on how I could conduct my own research in a more ethical manner. Soon I am to create and run my own workshop specifically on how to carry out ethical research in computational statistics and data science.

🤷 Other

Extra information: Native English, Spanish to good proficiency, UK drivers license, Dual UK and NZ nationality.

Hobbies: Photography based art, poetry, running (looking to do a marathon this year!), callisthenics, MMA, reading and listening to podcasts (novels, philosophy, history, science, travel writing, etc.), seeing the 🌍!

References

[1] Larry F Abbott. "Lapicque's introduction of the integrate-and-fire model neuron (1907)". In: *Brain research bulletin* 50.5-6 (1999), pp. 303–304.

[2] Matthias De Lange et al. "A continual learning survey: Defying forgetting in classification tasks". In: *IEEE transactions on pattern analysis and machine intelligence* 44.7 (2021), pp. 3366–3385.

[3] G Bard Ermentrout and Jack D Cowan. "A mathematical theory of visual hallucination patterns". In: *Biological cybernetics* 34.3 (1979), pp. 137–150.

[4] Chelsea Finn, Pieter Abbeel, and Sergey Levine. "Model-agnostic meta-learning for fast adaptation of deep networks". In: *International conference on machine learning*. PMLR. 2017, pp. 1126–1135.

[5] Robert M French. "Catastrophic forgetting in connectionist networks". In: *Trends in cognitive sciences* 3.4 (1999), pp. 128–135.

[6] Timothy Hospedales et al. "Meta-learning in neural networks: A survey". In: *IEEE transactions on pattern analysis and machine intelligence* 44.9 (2021), pp. 5149–5169.

[7] Michael McCloskey and Neal J Cohen. "Catastrophic interference in connectionist networks: The sequential learning problem". In: *Psychology of learning and motivation*. Vol. 24. Elsevier, 1989, pp. 109–165.

[8] German I Parisi et al. "Continual lifelong learning with neural networks: A review". In: *Neural networks* 113 (2019), pp. 54–71.

[9] Roger Ratcliff. "Connectionist models of recognition memory: constraints imposed by learning and forgetting functions." In: *Psychological review* 97.2 (1990), p. 285.