

Relevant Background:

One of the main directions of my work is investigating how sparsity can and does contribute to computation with neural networks. Sparsity influences the dynamics of learning to a great extent, so I have begun integrating control theory into the learning process itself. But the optimization controller does not initially know the model behaviour during optimization, and so must identify the model while controlling it – dual control. The combined system of the model being optimized and the optimization controller is a system that is responsible for adapting and changing itself – autopoietic. My category theory background comes largely from ‘Seven Sketches in Compositionality’, which I will complete by Feb 14th. I will then begin ‘Categories for the Working Mathematician’.

Ph.D information:

I expect to complete my Ph.D. December 2020. My thesis topic is: Spatio-temporal forecasting with sparse neural networks – an abstraction over the various ways of inducing and using sparsity for computation with neural networks.

Project preference order:

- 1) Toward a mathematical foundation for autopoiesis
- 2) Formal and experimental methods to reason about dialogue and discourse using categorical models of vector spaces
- 3) Complexity classes, computation, and Turing categories
- 4) Simplifying quantum circuits using the ZX-calculus
- 5) Traversal optics and profunctors
- 6) Partial evaluations, the bar construction, and second-order stochastic dominance

Travel commitment:

I have funding available to travel to Oxford July 22-26th and will likely attend the ACT conference July 15-19th.

Interest in ACT2019 school:

My interest in applied category theory comes from skimming the ‘Temporal Type Theory’ work, where I was enamoured with the idea of applying interpretable constraints to a dynamical system to guarantee behaviour. The further connections to generative design and robust project management are also alluring. I am specifically interested in the ACT2019 school because many of my research ideas appear to be very well expressed with categorical language, and I think I can meaningfully contribute to most of the available projects.

Information (I)

Lucien Koefoed

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<https://www.linkedin.com/in/lucien-koefoed-4495a6b9>

Currently attempting to mesh control theory with large scale spatio-temporal forecasting to achieve a delightful 3-tuple (independent of specific implementations): behavioural guarantees, absolute performance, and efficiency.

Education (Ed)

Ph.D., Mathematics and Computer Science, Auckland University of Technology, Dec 2017 – (est.) Dec 2020

Thesis: Spatio-temporal forecasting with sparse neural networks

Case studies: Convective weather forecasting (funded), Seismic hazard forecasting

Advisors: Prof. Nikola Kasabov, A/Prof. Wei Qi Yan

BE(Hons), Mechatronics, Robotics, and Automation Engineering, University of Auckland, Jan 2013 – Apr 2017

Honours thesis: Exception handling in project development: managing black swans

Advisor: Dr. David Wynn

Employment (Em)

Developer, Bright New Zealand, Dec 2016 – Nov 2017

C# application and library development, report design and automation

HVAC Engineering Intern, Numecon Contracting Ltd., Jan 2016 – Nov 2016

Control systems design and implementation, installation inspection, wiring

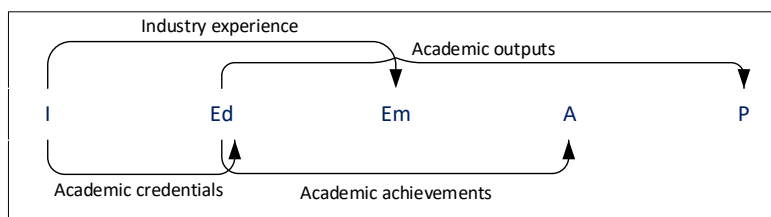
Awards (A)

KEDRI Scholarship, 2018 - 2020

Publications (P)

Koefoed, L., Capecci, E., & Kasabov, N. (2018, July). Analysis of Gene Expression Time Series Data of Ebola Vaccine response using the NeuCube and Temporal Feature Selection. In *2018 International Joint Conference on Neural Networks (IJCNN)* (pp. 1-7). IEEE.

Nandini, D., Capecci, E., Koefoed, L., Laña, I., Shahi, G. K., & Kasabov, N. (2018, December). Modelling and Analysis of Temporal Gene Expression Data Using Spiking Neural Networks. In *International Conference on Neural Information Processing* (pp. 571-581). Springer, Cham.



Statement in Support of Lucien Koefoed

Dear Admission Committee,

I am writing to give my unreserved support for Lucien Koefoed to be accepted in the Adjoint School, ACT 2019. I have known Lucien for one year, and in my capacity, as a Research Fellow, I have had ample opportunities to be aware of Lucien's contributions to the research at the Auckland University of Technology.

In the course of his studies, Lucien has demonstrated a thirst for knowledge that keeps him passionate about working and producing new mathematical methods and technologies in Artificial Intelligence, especially in the field of Spiking Neural Networks. His steady academic background, passion for science, and hard work allowed him to have the opportunity to collaborate in a project supported by New Zealand's Ministry of Business, Innovation & Employment.

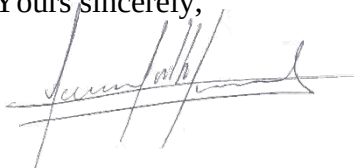
During this period, he has aimed towards understanding and applying spiking neural networks for natural phenomena (weather, earthquakes and volcanic earthquakes) forecasting tasks.

As chaotic systems, spiking neural networks need control mechanisms that keep the system in a critical state where the spiking activity is approximately sustained. He intends to apply category-theoretic tools for understanding and controlling the components of spiking neural networks that improve their learning capabilities for solving real-world classification/prediction tasks. I firmly believe that ACT 2019 is a fantastic opportunity for Lucien to learn more about category-theory.

I can confirm that Lucien is a person that counts on high knowledge in his area of specialty, has a high capacity for the development of abstract problems, and a firm commitment in all the tasks that he starts.

In sum, Lucien is a very gifted student and a true credit to the Auckland University of Technology. I recommend him, without reservation, for application to the Adjoint School, ACT 2019.

Yours sincerely,



Josafath I. Espinosa Ramos Ph.D.

Research Fellow

Knowledge Engineering and Discovery Research Institute

Auckland University of Technology

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