Manuel Baltieri, Ph.D.
Interdisciplinary researcher. Mathematical modeller. Coder.

Profile

- Interdisciplinary researcher synthesizing common threads across artificial life, neuroscience and artificial intelligence.
- Computational modeller turning abstract contexts into mathematical objects.
- Proficient coder developing simulations of complex systems in artificial worlds, biology and cognitive science starting from mathematical models.

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Professional Experience

Chief Researcher Oct 2022 - present
Researcher Nov 2021 - Sep 2022
Araya Inc.

Oct 2022 - present: Creating string diagrams of dynamical systems and control systems in applied category theory for models of decision making and reinforcement learning in general AI and mathematical theories of agent-environment interactions.

Nov 2021 - Sep 2022: Working on deep learning approaches to program synthesis and understanding. Focusing on Large Language Models (LLMs): architecture optimisation, fine-tuning, prompt engineering and performance metrics.

Lecturer (Part-time) Dec 2022 - Feb 2023
Center for Human Nature, Artificial Intelligence, and Neuroscience (CHAIN) - Hokkaido University, JP

Teaching a course on formal approached to the study of agency for the CHAIN 2023 Winter Graduate School.

Research Consultant and Developer Sep 2021 - Nov 2021
Nested Minds Network Ltd.

Writing Jax and (Num)Pyro code to support python development of active inference models, with applications to machine learning, robotics, economics and finance.

JSPS/Royal Society Postdoctoral Research Fellow Nov 2019 - Oct 2021
Center for Brain Science, RIKEN, Japan, with Taro Toyoizumi

Modelling brains in artificial and biological agents with Bayesian inference. Implementing collective intelligence and active matter simulations for perception of agency. Coding *'Generalised Filtering'* in Pytorch for active inference, learning and control.

Visiting Research Fellow in Informatics 2019 - present
University of Sussex, UK

Working on models on psychophysics experiments and supervising Master students.

Postdoctoral Research Fellow Mar 2019 - Oct 2019
University of Sussex, UK, with Christopher Buckley, Anil Seth, Warrick Roseboom

Implementing control as inference and active inference with Bayesian neural networks on robots. Coding models of uncertainty for psychophysics experiments.

Lecturer in Machine Learning (Fixed-term) Feb 2019 - Jun 2019
University of Sussex, UK

Teaching courses in Neural Networks and Fundamentals of Machine Learning.

Visiting Graduate Researcher Dec 2017 - Jan 2018
Earth-Life Science Institute (ELSI), Japan, with Olaf Witkowski, Nathaniel Virgo

Modelling origins of life with reaction diffusion systems, swarm chemistry and cellular automata. Analysing self-organising patterns with information theoretic measures.

Teaching Assistant 2015 - 2019
University of Sussex, UK

Data Science Research Methods, Computer Vision, Artificial life, Further Programming, Mathematical concepts.

Research Assistant Jan 2015 - Sep 2015

University of Sussex, UK, with Christopher Buckley

Building active inference generative models of suboptimal embodied artificial agents.

Education

Ph.D. in Informatics and Artificial Intelligence, University of Sussex, UK 2019

- Thesis: *"Active inference: building a new bridge between control theory and embodied cognitive science"*
- Supervisors: Christopher Buckley and Thomas Nowotny
- Examiners: Andy Clark and Daniel Polani

M.Sc. in Evolutionary and Adaptive Systems, University of Sussex, UK 2014

- Dissertation: *"A free energy principle for path tracking in a 1D world"*
- Supervisor: Simon McGregor

B.Eng. in Information and Business Organisation, Università di Trento, IT 2012

- Dissertation: *"A hybrid technique for the optimization of constrained portfolio problems"*
- Supervisors: Roberto Battiti and Mauro Brunato

Awards and grants

Fellowships and scholarships

- JSPS/Royal Society Postdoctoral Fellowship (**USD 80,000/ 2 years** from JSPS, Japan, selected by Royal Society, UK) 2019 - 2021
- Postdoctoral Fellowship (**USD 140,000/ 3 years** from oLife (Origins of Life) Fellowship Programme, The Netherlands; ***withdrawn*** *to accept JSPS/Royal Society Postdoctoral Fellowship* ~~2019-2022~~
- EON-ELSI Visiting Graduate Researcher Scholarship (**USD 5,000/ 2 months** from ELSI, Tokyo, Japan) Dec 2017-Jan 2018
- PhD Scholarship (**USD 60,000/ 3 years** from University of Sussex, UK) 2015-2018

Grants

- Kakenhi - Grant-in-Aid for Scientific Research (**USD 22,000/ 2 years**) 2019

Student Awards

- Merit prize (**USD 4,000** from University of Trento, Italy) 2012

Travel Awards (**USD 19,000**), from (among others)

- John Templeton Foundation, University of Sussex, Kyoto University, Hokkaido University, Okinawa Institute of Science and Technology, the Initiative for a Synthesis in Studies of Awareness, Guarantors of Brain (UK), the Society for Study of Artificial Intelligence and Adaptive Behaviour (UK), the Company of Biologists (UK)

Journal publications

- **Baltieri M.**, Iizuka, H., Witkowski, O., Sinapayen, L., & Suzuki, K. (2023). Hybrid Life: Integrating Biological, Artificial, and Cognitive Systems (2023). *WIREs Cognitive Science*. **(Invited)**
- Bruineberg J., Dolega K., Dewhurst J. & **Baltieri M.** (2022). The Emperor is Naked: Replies to the commentaries on the target article. *Behavioral and Brain Sciences*.
- Bruineberg J., Dolega K., Dewhurst J. & **Baltieri M.** (2021). The Emperor's New Markov Blankets. *Behavioral and Brain Sciences*.
- Mannella F., Maggiore F., **Baltieri M.** & Pezzulo G. (2021). Active inference through whiskers. *Neural Networks*.
- Hipólito, I., **Baltieri M.**, Friston, K., & Ramstead, M. J. (2021). Embodied skillful performance: Where the action is. *Synthese*, 1-25.
- **Baltieri M.**, & Buckley, C. L. (2019). PID control as a process of active inference with linear generative models. *Entropy, 21(3)*, 257.

Preprints and Work in progress

- **Baltieri M.** & Isomura T. (2021). Kalman filters follow the natural gradient of free energy at steady-state. *arXiv pre-print arXiv:2111.10530*
- **Baltieri M.** & Buckley C. L. (2020). On Kalman-Bucy filters, linear quadratic control and active inference. *arXiv pre-print arXiv:2005.06269*
- McGregor S., **Baltieri M.** & Buckley C. L. (2015). A minimal active inference agent. *arXiv pre-print arXiv:1503.04187*

Conference proceedings

- **Baltieri M.**, Buckley, C. L., & Bruineberg, J. (2020). Predictions in the eye of the beholder: an active inference account of Watt governors. In *Artificial Life Conference Proceedings - ALIFE 2020*. MIT Press.
- **Baltieri M.** (2020). A Bayesian perspective on classical control. In *2020 International Joint Conference on Neural Networks - IJCNN 2020*. IEEE.
- Tschantz A., **Baltieri M.**, Seth A. & Buckley C. L. (2020). Scaling Active Inference. In *2020 International Joint Conference on Neural Networks - IJCNN 2020*. IEEE.
- **Baltieri M.**, & Buckley, C. L. (2019). Active inference: computational models of motor control without efference copy. In 2019 Conference on Cognitive Computational Neuroscience.
- **Baltieri M.** & Buckley C. L. (2019). The dark room problem in predictive processing and active inference, a legacy of cognitivism? In *Artificial Life Conference Proceedings - ALIFE 2019*. MIT Press.
- **Baltieri M.**, & Buckley, C. L. (2019). Nonmodular architectures of cognitive systems based on active inference. In *2019 International Joint Conference on Neural Networks - IJCNN 2019*. IEEE.
- **Baltieri M.** & Buckley C. L. (2018). A probabilistic interpretation of PID control. In *International Conference on Simulation of Adaptive Behavior - SAB 2018)*. Springer.
- **Baltieri M.** & Buckley C. L. (2018). The modularity of action and perception revisited using control theory and active inference. In *Artificial Life Conference Proceedings - ALIFE 2018*. MIT Press.
- **Baltieri M.** & Buckley C. L. (2017). An active inference implementation of phototaxis. In *European Conference on Artificial Life Proceedings - ECAL 2017*. MIT Press.

Commentaries

- **Baltieri M.** and Buckley C. L. (2019). Generative models as parsimonious descriptions of sensorimotor loops. (Commentary to Brette R. (2019): Is coding a relevant metaphor for the brain?) *Behavioral and Brain Sciences*. Cambridge University Press.

Other publications

- **Baltieri M.** (2021). Thinking about robots., A contributed chapter to *Robot 100* https://www.robot100.cz/book.
- **Baltieri M.** (2018). Information and regulation at the origins of life. (Blogpost for EON - ELSI)

Invited presentations

Inference with and within a model CHAIN Academic Seminars, Hokkaido University, Sapporo, Japan — Feb 2023

Inference with and within a model, Consciousness Club, Tokyo, Japan — Jul 2022

Variational inference in agents, with connections to control theory and cognitive (neuro)science, RIKEN AIP, Tokyo, Japan — Jul 2021

Agency in 100 years, a solved problem? Discussion with Kevin O'Regan at Tokyo ALIFE 2020 (University of Tokyo and Google Brain), Tokyo, Japan — Mar 2020

(Notes: Postponed due to COVID-19, Sep 2020; new program with limited number of invited speakers)

Active inference for cognitive science and artificial intelligence - open questions and new challenges CHAIN Academic Seminars, Hokkaido University, Sapporo, Japan — Jan 2020

PID control as active inference: what can we gain from this formulation?, 2nd Active inference workshop, TU Delft, Delft, Netherlands Nov 2018

The free energy principle and active inference, connecting control theory to biology, Active inference workshop, TU Delft, Delft, Netherlands Apr 2018

Selected presentations

The Emperor's New Markov Blankets, Annual meeting of the Association of Scientific Studies of Consciousness (ASSC 25) 2022, Amsterdam, Netherlands Jul 2022

Predictions in the eye of the beholder: an active inference account of Watt governors, International Conference on Artificial Life (ALIFE) 2020, Montreal, Canada Jul 2020

A Bayesian perspective on classical control, International Joint Conference on Neural Networks (IJCNN) 2020, Glasgow, UK Jul 2020

The dark room problem in predictive processing and active inference, a legacy of cognitivism?, International Conference on Artificial Life (ALIFE) 2019, Newcastle, UK Jul 2019

Nonmodular architectures of cognitive systems based on active inference, International Joint Conference on Neural Networks (IJCNN) 2019, Budapest, Hungary Jul 2019

A probabilistic interpretation of PID controllers using active inference, International Conference on the Simulation of Adaptive Behaviour (SAB) 2018, Frankfurt, Germany Aug 2018

The modularity of action and perception revisited using control theory and active inference, International Conference on Artificial Life (ALIFE) 2018, Tokyo, Japan Jul 2018

The free energy principle and active inference, connections to 4Es views of cognition Friston Lab - Theoretical neurobiology meeting @ Wellcome Trust Centre for Neuroimaging, UCL, London, UK Mar 2018

The free energy principle for the study of action and perception

- Honda Research Institute Japan Co. Ltd. (HRI-JP) - Department Intelligence Science & Technology, Kyoto University, Kyoto, Japan Jan 2018
- Ikegami Laboratory - Department of General Systems Sciences, University of Tokyo, Japan Jan 2018
- Laboratory for Neural Computation and Adaptation - RIKEN Center for Brain Science, Saitama, Japan Dec 2017

An active inference implementation of phototaxis, European Conference on Artificial Life (ECAL) 2017, Lyon, France Sep 2017

Professional Service

Editing:

Editor for the Proceedings of the the Artificial Life Conference 2023, Mit Press 2023
Topical Advisory Panel for Entropy - MDPI 2021 - present
Guest Editor for Special Issue on *"Emerging Methods in Active Inference"*, Entropy - MDPI 2021

Organising:

Proceedings/Local Chair of ALIFE 2023 (Sapporo, Japan), 2023
Co-Organiser of ALIFE 2022 (Trento, Italy - online), 2022
Lead Co-Organiser of *"Hybrid life: Approaches to integrate biological, artificial and cognitive systems"*. Created and primarily managed four special sessions, coordinating advertisement, speakers' invitations, reviewing and editing processes of the submissions for four years.

- Hybrid Life V at ALIFE 2022 (Trento, Italy - online), 2022
- Hybrid Life IV at ALIFE 2021 (Prague, Czech Republic - online), 2021
- Hybrid Life III at ALIFE 2020 (Montreal, Canada - online), 2020
- Hybrid Life II at ALIFE 2019 (Newcastle, UK), 2019
- Hybrid Life I at ALIFE 2018 (Tokyo, Japan) 2018

Co-Organiser of *"ALife for Social and Environmental Good"* at ALIFE 2020, Montreal, Canada (online) 2020

Lead Organiser of ALERGIC (Artificial LifE Reading Group In Cogs) seminars, Evolutionary and Adaptive Systems group, University of Sussex, UK. Invited and hosted sessions for 20-30 speakers, mainly from European countries, organising their visits and meetings with different research groups. 2017 - 2018

Reviewing:

Reviewer for

- NWO (Dutch research council) - Applied and Engineering Sciences
- Nature Communications, PNAS, Interface Focus, Biological Cybernetics, Brain, Physics of Life Reviews, Journal of Neuroscience Methods, Entropy - MDPI, Mathematics - MDPI, Neuroscience and Behavioural Reviews, Autonomous Agents and Multi-Agent Systems, The Journal of Theoretical Biology, Frontiers in Computational Neuroscience, Frontiers in Psychology, Philosophy and the Mind Sciences, Computational Psychiatry, Hearing, Adaptive Behavior, Journal of Consciousness Studies, Neuroscience of Consciousness
- (Conferences) Artificial Life (ALIFE), Cognitive Computational neuroscience (CCN), Intelligent Robots and Systems (IROS), Workshop on "From Cells to Societies: Collective Learning Across Scales" (ICLR)

Meta-reviewer for Artificial Life (ALIFE) conferences

Outreach

JSPS Science Dialogue for High School students, Fukushima, Japan (online) 2021
Meetings with researchers for High School students, Verona, Italy (online) 2021
JSPS Science Dialogue for High School students, Tokyo, Japan 2020
Widening Participation (University of Sussex), UK 2015
Brighton Science Festival volunteer, Brighton, UK 2015

Special Courses and Schools

Teaching:

CHAIN Winter School on Minimal Cognition and Agency 2023

Attending:

Computational Psychiatry Course, UCL, London, UK 2017
Computational Neuroscience, OIST, Okinawa, Japan (15% accepted applications) 2017
ISSA Summer School, Osaka, Japan (12.5% accepted applications) 2017
Computational Psychiatry Course, ETH Zurich, Switzerland 2016

Coding and scripting

Python, C, C++, Java, Cobol, Visual Basic, Fortran 77, Logo, Pascal, Bash, XML, SQL, MySQL, Matlab, and others

Languages

- Venetian - Native
- Italian - Native
- English - Fluent
- Spanish - Conversational
- French - Conversational
- Japanese - Elementary

References

Christopher Buckley c.l.buckley@sussex.ac.uk
Senior Lecturer in Neural Computation
School of Engineering and Informatics, University of Sussex

Anil Seth a.k.seth@sussex.ac.uk
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School of Engineering and Informatics, University of Sussex

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Head of the School of Engineering and Informatics,
School of Engineering and Informatics, University of Sussex

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Research Scientist, Earth-Life Science Institute (ELSI), Tokyo Institute of Technology

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