

Olaf WITKOWSKI

Lead AI Research Scientist
From Machine Intelligence to Artificial Life

Tokyo Institute of Technology
2-12-1-IE-1 Ookayama, Meguro-ku
Tokyo-to 152-8550, Japan
+81 90 6494 1268
olaf.witkowski@gmail.com

Experience

- 2019 – present Director of Scientific Affairs & Chief Scientist, **Cross Research Institute**, Cross Compass Ltd., Tokyo.
Leading a research institute for the fundamental principles of intelligence, at the intersection between industrial research and scientific progress, toward and beyond human-level cognition.
- 2016 – present Research Scientist, **Earth-Life Science Institute**, Tokyo Institute of Technology.
Modeling the emergence of information flows which led to distributed intelligence in living systems.
Visiting Research Fellow, **Institute for Advanced Study**, Princeton.
Co-Founder and Research Architect, **YHouse Inc.**, New York.
- 2015 – 2016 Postdoctoral Fellow, Graduate School of Arts and Sciences, University of Tokyo.
Created multiagent neural network based models of massive swarm intelligence.
- 2013 – 2016 Research Scientist in Machine Learning, Advanced Technology Department, MTI Ltd.
Designed a music recommendation system and an AI/NLP scientist for gene expression analysis.
- 2009 – 2011 Research Assistant, Tsujii Lab, University of Tokyo.
Developed a UIMA Natural Language Processing toolkit.
- 2007 – 2009 Co-Founder & Chief Research Officer, Commentag LLC.
Designed the first semantic search engine for Microblogging – Tweetag.com, which became Storify.com.
- 2007 – 2008 Teaching and Research Assistant, Info. Sys. Unit, Louvain School of Management.

Education

- 2011 – 2015 Doctor's Degree in Computer Science, Graduate School of Information Science and Technology, University of Tokyo.
Thesis Evolution of Coordination and Communication in Groups of Embodied Agents
Supervisor Prof. Takashi IKEGAMI, Graduate School of Arts and Sciences, University of Tokyo.
- 2007 – 2008 Master's Course in Natural Language Processing (1 year), Center for Natural Language Processing, University of Louvain (UCL).
- 2004 – 2007 Master's Degree in Computer Science and Engineering, specialized in Artificial Intelligence, Department of Computer Science, UCL.
- 2001 – 2004 Bachelor's Degree in Engineering, Faculty of Applied Sciences, UCL.

Languages

French	Mother tongue
English	Fluent
Spanish	Fluent
Polish	Fluent
Vietnamese	Fluent
Japanese	Conversational
Portuguese	Conversational
Italian	Basic
Russian	Basic
Dutch	Basic
Chinese	Basic
Latin	Basic

Expertise

Background: Artificial Life, Neural Networks, Evolutionary Computation, Game & Information Theory, Mathematical Biology, Cryptography, Linguistics.

Teaching: Software Engineering, Machine Learning (2 undergraduate courses). Evolutionary Robotics, Artificial Chemistry, Agent-Based Modeling (mentored 2 graduate and 2 undergraduate students to graduation). Cognitive Science, Robotics (taught 2 summer schools).

Fluent: Java, Oz, Python. *Very good:* Assembly, C, C++, Fortran, Grails, Javascript, Matlab, PHP, R, SQL, Tex, VHDL. *Good:* Objective C, Prolog, Ruby, Smalltalk.

Current Research: From Cognitive Life to Machine Intelligence

In all of life on Earth, from cells, to swarms, to brains and societies, intelligence can be understood in terms of **self-maintaining information flows through time and space**. Information's substrate-independence and interoperability made possible for symbolic representations such as the genetic code to parasitize the laws of physics. These patterns progressively became more complex, going through major transitions which gave rise to large varieties of self-correcting patterns. These steps correspond to **transitions in ever-increasing intelligence and creativity**, a phenomenon also known as open-ended evolution.

The key to understanding the emergence and dynamics of these transitions can be found in the way spatiotemporal entities process and exchange information between each other, that is, the causal structure of their sensorimotor loops and information trading patterns. **Replicating these intelligent mechanisms artificially within computers** – either recent von Neumann architectures or more unconventional computing such as chemical computing – can enable us to factor out the fundamental principles of life in the universe, and characterize formally the nature of concepts such as cognition, autonomy, complexity, cooperation and integration.

In my research, I explore how techniques from artificial life modeling, machine learning and information theory can help us characterize the **physical laws of intelligence, giving rise to the emergence of open-ended intelligence in the universe**. By understanding these laws, we may start constructing machine intelligence that helps humans, today!

Publications

Google Scholar: https://scholar.google.be/citations?user=B_XJHVkAAAAJ

Journal Papers

Witkowski, O. and Guttenberg, N. (in preparation). Transfer of Knowledge via Differentiably Learned Language. *Frontiers in Robotics and AI*.

Witkowski, O. (pending review). Expansion of Collective Intelligence: A Model of Distributed Computation among Signaling Agents. Special Issue, Computational Intelligence and Neuroscience in Neuro-robotics.

Mariscal, Carlos et al. (pending review). The History and Philosophy of Origins-of-Life Studies: Orientations for the Future. Submitted to *Biological Reviews*.

Khajehabdollahi, S. and Witkowski, O. (in press). Adaptive Criticality: Exploring the Trade-Off Between Learning and Evolution with Embodied Boltzmann Machines. Special Issue, *Artificial Life*.

Witkowski, O. and Ikegami, T. (2018) How to make swarms open-ended? Evolving collective intelligence through a constricted exploration of adjacent possibilities". Special Issue on Open-Ended Evolution, *Artificial Life Journal*.

Miyahara, K. and Witkowski, O. (2018) The integrated structure of consciousness: phenomenal content, subjective attitude, and noetic complex. *Journal of Consciousness Studies*, Springer Nature. DOI: 10.1007/s11097-018-9608-5.

Drozd, A., Witkowski, O., Matsuoka, S. and Ikegami, T. (2016). Critical Mass in the Emergence of Collective Intelligence: a Parallelized Simulation of Swarms in Noisy Environments. *Artificial Life and Robotics* 21.3: 317-323.

Witkowski, O., and Ikegami, T. (2016). Emergence of Swarming Behavior: Foraging Agents Evolve Col-

lective Motion Based on Signaling. *PloS one* 11.4 (2016): e0152756.

Scharf, C., Virgo, N., Cleaves, H. J., Aono, M. et al. (2015). A Strategy for Origins of Life Research. *Astrobiology* 15.12: 1031-1042.

Peer-Reviewed Papers

Khajehabdollahi, S. and Witkowski, O. (2018). Critical Learning vs. Evolution: Evolutionary Simulation of a Population of Ising-Embodied Neural Networks. In *Artificial Life Conference Proceedings* (pp. 47-54). One Rogers Street, Cambridge, MA 02142-1209 USA journals-info@mit.edu: MIT Press.

Ikegami, T., Virgo, N., Witkowski, O., Oka, M., Suzuki, R. and Iizuka, H. (2018). Beyond AI: A New Epistemology for Artificial Life and Complex Systems, an Introduction to the 2018 ALIFE conference. In *Artificial Life Conference Proceedings* (pp. 1-4). One Rogers Street, Cambridge, MA 02142-1209 USA journals-info@mit.edu: MIT Press.

Witkowski, O. and Nitschke, G. (2018). The dynamics of cooperation versus competition. In *Proceedings of the Genetic and Evolutionary Computation Conference Companion* (pp. 115-116). ACM.

Bartlett S. J., Witkowski O. and Giovannelli D. (2017). Cognition and Learning: A Primary Determinant and Seed of Life. In *Proceedings of XVIIIth Intl Conf on Origin of Life 2017 (LPI Contrib. No. 1967)* at UC San Diego, CA, USA.

Aubert-Kato, N., Witkowski, O., Hoel, E. and Bredeche, N. (2016). Towards Detecting the Emergence of Agency in Evolved Artificial Chemistries. *Artificial Life XV: Late-Breaking Proceedings of the Fifteenth International Conference on the Synthesis and Simulation of Living Systems*, 20-21.

- Witkowski, B. and Witkowski, O. (2016). City's Evolution: Vernacular or Sustainable? In: P. Hajek, J. Tywionak, A. Lupisek, Katerina Sojkova (eds.), CESB16: Proceedings of the Central Europe towards Sustainable Building Conference 2016, 635-642.
- Witkowski, O. and Ikegami, T. (2015). Swarm Ethics: Evolution of Cooperation for Multi-Agent Foraging Model. Proceedings of the First International Symposium on Swarm Behavior and Bio-Inspired Robotics.
- Drozd, A., Witkowski, O., Matsuoka, S. and Ikegami, T. (2015). Signal-Driven Swarming: A Parallel Implementation of Evolved Autonomous Agents to Perform A Foraging Task. Proceedings of the First International Symposium on Swarm Behavior and Bio-Inspired Robotics.
- Aubert-Kato, N., Witkowski, O. and Ikegami, T. (2015). The Hunger Games: Embodied agents evolving foraging strategies on the frugal-greedy spectrum. In: P. Andrews, L. Caves, R. Doursat, S. Hickinbotham, F. Polack, S. Stepney, T. Taylor and J. Timmis (eds.), ECAL 2013: Proceedings of the Thirteenth European Conference on Artificial Life, MA: MIT Press, 13, 357-364.
- Witkowski, O., Nitschke, G. and Ikegami, T. (2015). Signal drives genetic diversity: an agent-based approach to speciation. Proceedings of the Twentieth International Symposium on Artificial Life and Robotics, Springer Japan, 20, 74-77.
- Witkowski, O. and Aubert-Kato, N. (2014). Pseudo-static cooperators: Moving isn't always about going somewhere. In: H. Sayama, J. Rieffel, S. Risi, R. Doursat and H. Lipson (eds.), Artificial Life XIV: Proceedings of the Fourteenth International Conference on the Simulation and Synthesis of Living Systems, MA: MIT Press, 14, 392-397.
- Witkowski, O. and Ikegami, T. (2014). Asynchronous evolution: Emergence of signal-based swarming. In: H. Sayama, J. Rieffel, S. Risi, R. Doursat and H. Lipson (eds.), Artificial Life XIV: Proceedings of the Fourteenth International Conference on the Simulation and Synthesis of Living Systems, MA: MIT Press, 14, 302-309.
- Witkowski, O. and Nitschke, G. (2013). The Transmission of Migratory Behaviors. In: P. Liò, O. Miglino, G. Nicosia, S. Nolfi and M. Pavone (eds.), ECAL 2013: Proceedings of the Twelfth European Conference on Artificial Life, MA: MIT Press, 12, 1218-1220.
- Witkowski, O. and Aubert, N. (2012). Size Does Matter: The Impact of Size on Hoarding Behaviour. In: C. Adami, D. M. Bryson, C. Ofria and R. T. Pennock (eds.), Artificial Life XIII: Proceedings of the Thirteenth International Conference on the Synthesis and Simulation of Living Systems, Cambridge, MA: MIT Press, 13, 542-543.
- Witkowski, O., Nitschke, G. and Ikegami, T. (2012). When is happy hour: An agent's concept of time. In: C. Adami, D. M. Bryson, C. Ofria and R. T. Pennock (eds.), Artificial Life XIII: Proceedings of the Thirteenth International Conference on the Synthesis and Simulation of Living Systems, Cambridge, MA: MIT Press, 13, 544-545.
- McCrohon, L. and Witkowski, O. (2011). Devil in the details: Analysis of a coevolutionary model of language evolution via relaxation of selection. In: T. Lenaerts, M. Giacobini, H. Bersini, P. Bourguine, M. Dorigo, and R. Doursat (eds.), Advances in Artificial Life, ECAL 2011: Proceedings of the Eleventh European Conference on the Synthesis and Simulation of Living Systems, Cambridge, MA: MIT Press, MIT Press, 522-529.

Non Peer-Reviewed Papers

- Markovitch, O., Witkowski, O. and Virgo, N. (2018). Chemical Heredity as Group Selection at the Molecular Level. arXiv preprint arXiv:1802.08024.
- Guttenberg, N., Virgo, N., Witkowski, O., Aoki, H. and Kanai, R. (2016). Permutation-equivariant neural networks applied to dynamics prediction. arXiv preprint arXiv:1612.04530.

Dissertations

- Witkowski, O. (2015). **Evolution of Coordination and Communication in Groups of Embodied Agents.** PhD thesis, Library for Engineering and Information Science & Technology, University of Tokyo.
- Witkowski, O. (2007). **Decrypting Khipu Cords Used by Incas as a Means of Communication: an Example of Ethno-Cryptography.** MSc thesis, Library of Exact Sciences, Catholic University of Louvain.

Conferences Presentations

- Witkowski, O. (July 2018). The Future of Collective Intelligence: Investigating the Impact of High-Dimensional Sphere Packing and Massively Multichannel Societies on Communication with Evolutionary Simulation. The 2018 Conference on Artificial Life.
- Witkowski, O. (April 2017). Information Flows, Connectionist Learning and the Transition to Collective Cognition. AI With The Best, International Online Conference. April 29-30, 2017.
- Witkowski, O. (July 2017). The Emergence of Cognition as Parasitic Information Flows, Artificial Life Workshop, July 22, 2017.
- Witkowski, O. (August 2016). Representing Information Flows in the Major Transitions to Complex Life and Cognition. History and Philosophy of Origins Research Workshop at ELSI, Tokyo, Japan. August 24-26, 2016.

Aubert-Kato, N., Witkowski, O., Hoel, E. and Bredeche, N. (July 2016). Decision Making in Messy Chemistries: Case Study with an Invasion-based Reaction Diffusion Scenario. Proceedings of the International Conference on Unconventional Computation and Natural Computation.

Witkowski, O., Nitschke, G. and Ikegami, T. (March 2012). Time To Migrate: The Effect of Lifespan on Imitation and Culturally Learned Migration. Seventh International Workshop on Natural Computing.

Witkowski, O. (September 2011). A Two-Speed Language Evolution: Exploring the Linguistic Carrying Capacity. Proceedings of the International Conference: Ways to Protolanguage 2.

Witkowski, O. (July 2011). Can Cultural Adaptation Lead to Evolutionary Suicide? Proceedings of the Twenty-Third Annual Human Behavior & Evolution Society Conference (HBES 2011).

Witkowski, O. (August 2010). A Two-Speed Language Evolution. Proceedings of the Fourth Annual International Free Linguistics Conference.

Honors & Fellowships

- 2016 – present ELSI Origins Network Postdoctoral Fellowship Grant, supported by the John Templeton Foundation; Study Title: “Information Flows in the Major Transitions of Evolution”. Hosting Institutions: Earth-Life Science Institute, Tokyo Institute of Technology & Institute for Advanced Study.
- 2010 – 2013 MEXT Monbukagakusho Scholarship from Japanese Government for PhD Program. Hosting Institution: University of Tokyo (Ikegami Lab/Artificial Life).
- 2008 – 2010 MEXT Monbukagakusho Scholarship from Japanese Government for Independent Research Project. Hosting Institution: University of Tokyo (Tsujii Lab/Natural Language Processing).
- 2010 IST International Research Program Fellowship, Université du Québec à Montréal (UQAM), Canada.
- 2008 Grant for Student Mobility for Internships, Hosting Institution: University of Sheffield (UK).
- 2007 Obtained the protected title of Civil Engineer, with Honors (UCL, Belgium).
- 2006 – 2007 Erasmus European Scholarship for Master’s Students. Hosting Institution: Polytechnic University of Valencia (Spain).

Invited Talks & Workshops

- 2018 *What is the Foundation for a Theory of Life?* ASU-SFI Origin of Life Theory Working Group Meeting. Global Biosocial Complexity Initiative Space, Arizona State University, USA. November 11-13.
- 2018 *Novelty?!! Characterizing Open-Ended Evolution from Origins of Life to Artificial Intelligence.* Invited talk at Arizona State University, USA. November 13.
- 2018 *Swarm AI: How Life Can Evolve Higher Forms of Cognition.* After Hours Conversation Talk, Institute for Advanced Study, Princeton, USA. October 29.
- 2018 *The Future of Artificial Life Research.* ALife Roadmap Workshop. ALIFE 2018 Conference, Tokyo, Japan. July 23-27.
- 2018 *Evolution of Life through the Lens of Computation.* Leslie Valiant Lab, Harvard University, Boston, USA. June 15-16.
- 2018 *From Life to Brains: The Emergence of Collective Computation.* McGill University, Montreal, Canada. February 21.
- 2017 *Information Flows, Connectionist Learning and the Transition to Collective Cognition.* AI With The Best, International Online Conference. April 29-30.
- 2017 *Characterizing Cognition as Information Flows.* Cognition Lunch Salon, Princeton, USA. March 23.
- 2017 *When Do Autonomous Agents Act Collectively?* Biological Complexity: Can It Be Quantified? Beyond Center Workshops on the Physics of Living Matter. Institute for Advanced Study, Princeton, USA. February 1-3.

- 2016 *Representing Information Flows in the Major Transitions to Complex Life and Cognition*. History and Philosophy of Origins Research Workshop at ELSI, Tokyo, Japan. August 24-26.
- 2016 *Complex Systems & Artificial Life*. Institute for Advanced Study, Princeton, USA. February 2-March 30.
- 2015 *Signal-Driven Swarm Intelligence and Evolutionary Robotics*. Molecular Robotics Symposium, Tokyo, Japan. October 28.
- 2015 *Deep Learning and Swarm Intelligence: Towards Higher Levels of Cognition*. University of Cape Town, Cape Town, South Africa. September 7-11.
- 2015 EON International Roadmap Workshop, ELSI, Tokyo, Japan. August 28.
- 2015 EON Workshop on the Spontaneous Emergence of Autonomous Agents in Complex Systems, Kobe, Japan. August 12-14.
- 2015 *The Value of Signals in the Evolution of Collective Behavior*. Workshop on Artificial Life and Embodied Systems. Institute of Intelligent Systems and Robotics, Paris, France. June 25.
- 2015 *Evolution of Coordination to Cooperation to Language: An Artificial Life Approach*. Sackler Centre for Consciousness Science, University of Sussex, UK. July 25.
- 2015 *Open-Ended Modeling: How to Make Artificial Life Do Better At Studying Real Life?* Workshop on Artificial Life and Open-Ended Evolution at ELSI, Tokyo, Japan. May 21.
- 2013 *Time To Migrate: The Effect of Lifespan on Imitation and Culturally Learned Migration*. Seventh International Workshop on Natural Computing, Tokyo, Japan. March 21.
- 2012 *Evolution of Artificial Communication in Embodied Agents: The Impact of Temporal Concept on Communicative Behavior*. Artificial Life Summer Workshop, Sapporo, Japan. August 2-3.
- 2012 *Size Does Matter: The Impact of Size on Hoarding Behaviour*. Bio UT International Life Sciences Symposium, Tokyo, Japan. May 21.
- 2011 *A Two-Speed Language Evolution: Exploring the Linguistic Carrying Capacity*. International Conference Protolang 2, Torun, Poland. September 19-21.
- 2011 *Language Evolution in a Population of Simulated Agents*. Artificial Life Summer Workshop, Yamanaka, Japan. July 23-25.

Organizational Roles & Research Management

- 2019 Co-organizer of “Hybrid Life” Workshop at ALIFE 2019 (UK)
- 2019 General Chair of ELSI “Fundamental Principles of Life” Workshop, first event of the “Meeting of Experts”, co-organized by ELSI and the University of Tokyo
- 2019 Program Chair of 7th ELSI International Symposium on Origins of Life “Comparative Emergence”
- 2018 **Program Chair of ALIFE 2018 – the 2018 International Conference on Artificial Life, themed “Beyond AI”** held July 23rd-27th in Tokyo (First edition of a unified international conference in artificial life, unifying the major meetings in the Artificial Life field, ECAL and ALIFE, started in 1987).
- 2018 Co-Organizer of Workshop “Leslie Valiant’s Learning Vision”, School of Engineering and Applied Sciences, Harvard University
- 2018 – present **Research Coordinator for the ELSI Origins Network (EON) project, a global network of researchers working on the origins of life.** EON was created to form a world-wide and interdisciplinary network for research into the Origin of Life, to pursue leading-edge research at ELSI, in TokyoTech and throughout the whole network, and to internationalize research and higher education in Japan.

- 2017 – present **Co-Founder and Chief Research Architect at YHouse Inc., nonprofit transdisciplinary research institute focused on the study of awareness, artificial intelligence and complex systems**, New York City. Although YHouse Inc. got officially incorporated in July 2017, activities started in February 2016. Experience: coordinated the development of 14 research projects, and formed a network including 18 top universities and research institutions, ending up fundraising over **US\$100,000** over the first two years of the organization.
- 2016 – present Co-Organizer of the IAS Cognition Lunch, weekly interdisciplinary academic meeting at the Institute for Advanced Study (Princeton)
- 2016 – present **Founder and Principal Organizer of the Consciousness Club, biweekly interdisciplinary science outreach event** in New York City – over 1000 members.
- 2016 – 2017 Scientific Board for Conscious Machine Project (CREST Grant “Towards constructing artificial consciousness based on the integrated information theory”, ARAYA Brain Imaging)
- 2016 Scientific Team for the Strategy for Origins of Life Research (SOLR) Roadmap Workshop
- 2015 – present Chair of Coordinating Committee for Initiative for a Synthesis in Studies of Awareness (ISSA), organizing joint research projects and biennial summer schools
- 2011 – present Member of International Society for Artificial Life (ISAL)
- 2010 – present Organizing Member of Tokyo Evolutionary Linguistics Group
- 2007 – 2009 Founder & Leader of Research Department in Machine Learning and Natural Language Processing, at Commentag LLC.
- 2006 – present Member of MIT Khipu Research Group (CSAIL, MIT)

Review Editorial Boards

- 2018 – present Phenomenology and the Cognitive Sciences; New Journal of Physics; Cognitive Systems; Research Special Issue on Social Learning and Cultural Evolution; International Journal of Control
- 2017 – present Biosystems Journal; Frontiers in Physics; Adaptive behavior
- 2016 – present Artificial Life, Journal of the International Society for Artificial Life
- 2015 – present International Conference on the Synthesis and Simulation of Living Systems (Annual PC); International Symposium on Swarm Behavior and Bio-Inspired Robotics (Biennial PC)
- 2013 – present Evolutionary Robotics for the Journal Frontiers in Robotics and AI

Outreach Activities

- 2018 “Collective Intelligence: Emergence of Language in the Universe”. University of Kathmandu, November 26, 2018.
- 2018 EON Interdisciplinary Talk: “The Collective Computation of Life: Emergence and Expansion of Cognition in the Universe”, EON Annual Meeting, Tokyo. January 5-6.
- 2017 Nerdnite Talk: “Befriending the Alien: Expansion of Intelligence in the Universe”, Nagatacho GRID, Tokyo. December 15.
- 2017 IAS Lunch Talk: “Ethics and AI”, Program for Interdisciplinary Studies, Institute of Advanced Study, Princeton. March 8.
- 2017 Talk for the AMIAS board of trustees: “The Collective Computation of Life” (see abstract towards the end of this file), Institute for Advanced Study, Princeton. November 3.
- 2017 Talk at Cognition Lunch Salon: “Characterizing Cognition as Information Flows”, Institute for Advanced Study, Princeton. March 23.
- 2017 Public Talk at WeWork: “The Collective Computation of Life”, New York, October 25.
- 2016 Public Talk at Consciousness Club: “AlphaGo and the Future of AI”, New York. October 12.