Editorial: The 2019 Conference on Artificial Life Special Issue

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This special issue highlights key selections from the 2019 Conference on Artificial Life, ALIFE'19, hosted by Newcastle University in Newcastle upon Tyne, UK. The annual conference addresses the synthesis and simulation of living systems.

The special theme of the 2019 conference was *"How Can Artificial Life Help Tackle Societal Challenges?"* We claim that our interdisciplinary and constantly self-innovating research community brings together a set of skills and perspectives with a unique potential to tackle some of the most pressing societal challenges of our times. This theme ran through the conference in the shape of keynote presentations and satellite events that apply Artificial Life principles to research on, e.g., social dynamics, cultural evolution and societal learning, human behaviour, and smart cities, to name only a few.

Adhering to the overarching theme quite practically, ALIFE'19 was organized as a demonstrator for sustainable conferencing: The event pioneered the inclusion of remote participation (one year prior to the COVID19 pandemic); the conference served a locally sourced, red-meat free diet; and typical sources of waste were prevented by providing participants with reusable tumblers and an electronic conference program in place of throw-away material and printed booklets.

The conference featured 108 oral and poster presentations, which were published in the conference proceedings (Fellermann et al., 2019). The programme also entailed eight keynote presentations to demonstrate potential applications of Artificial Life research for societal benefit as well as nine satellite workshops, many of them exploring these directions further.

This special issue presents five extended versions of outstanding conference submissions that contribute to classic research areas of artificial life: evolution and evolutionary computing, neural networks, self-replication, artificial chemistries, robotics, gene regulatory networks, agent-based simulation, robustness, modularity, and emergence.

In the field of artificial evolution and evolutionary programming, Langdon and Banzhaf present a study on long-term genetic program evolution of program trees that were run over a million generations and produced trees of up to two billion instructions. The authors observed ongoing, potentially open-ended evolution, but also concluded that deep expressions might be resilient to

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learning as they disperse information, impeding evolvability and the adaptation of highly nested organisms.

Gabor et al. present an innovative study that connects the field of neural networks to the one of self-replicating automata. To achieve this, they introduce a diagonalization of neural networks that enables networks to operate over diagonalized network representations. In their study "Self-Replication in Neural Networks," the authors analyse how various network encodings can give rise to non-trivial self-replicators that are robust to noise. They also present an interesting artificial chemistry environment consisting of several neural networks and the emergent behavior when these networks are allowed to operate on each other.

A study by Miras and Eiben demonstrates the effects of changing environments on evolution. When evolving robotic bodies and brains in a changing environment, they observe a "genetic memory" where solutions evolved under a gradually changing environment differ from the ones obtained when robots are directly evolved in the final environment. In particular they can demonstrate that solutions achieve higher fitness as well as stronger robustness when evolved in an environment with gradually increasing levels of difficulty, suggesting that evolutionary learning strategies are superior when training follows a careful designed "pedagogical" strategy.

Qin, Gedeon, and McKey present new findings on robustness and modularity in the study of artifically evolved gene regulatory network models. By developing a novel method to evaluate the fitness of evolved gene regulatory networks, the authors are able to derive theoretical bounds on the fitness and to differentiate the effects of the problem domain from those of a commonly stochastic fitness evaluation. The authors reveal important properties of optimized gene regulatory networks that lead to robustness and modularity and discuss potential directions towards understanding the emergence of modularity in larger, more complex domains, which is key both to generating more useful modular solutions and to understanding the ubiquity of modularity in biological systems.

Finally, Marriott, Bae, and Chebib implement an agent-based simulation of reproductive division of labor. Agents in their simulation must perform two tasks in their environment: forage and reproduce. The colony is capable of allocating resources to these roles using different division of labor strategies via genetic architectures and plasticity mechanisms. They find that a deterministic allocation strategy of the response threshold model is more robust than a probabilistic allocation strategy. The deterministic allocation strategy is also capable of evolving complex solutions to colony problems like niche construction and recovery from loss of a breeding caste.

The ALIFE community proved its readiness to evolve towards sustainability and to adapt to novel challenges. This holds with respect to science, as can be seen in this volume. But this community is also willing to develop its organisational structure further, to reflect about its own role and to draw conclusions from these reflections.

In the present time, where powerful youth movements as well as politicians with foresight appeal to unite behind the sciences, the ALIFE community has the big opportunity and responsibility to contribute to a sustainable future. ALIFE'19 gives a reason for an optimistic outlook; the field of and the researchers in Artificial Life can and will master their role!

Reference

Fellermann, H., Bacardit, J., Goñi-Moreno, Á., & Füchslin, R. M. (2019). *The 2019 conference on Artificial Life*. Newcastle University Library eprint. https://direct.mit.edu/isal/isal2019/volume/31