Submission for Virtual Creature Contest 2024

Bootstrapping the open-ended evolution of artificial creatures in Flow-Lenia

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1 Why: Achieving open-ended evolution in ALife

How can certain components of an initially lifeless environment self-organize to form the first individuals and bootstrap their evolution? In an artificial life context, these first individuals are seen as emergent self-organizing structures capable of self-constitution, self-maintenance, and possessing certain functionalities to ensure their survival and reproduction, thereby initiating an evolutionary process that allows their proliferation and diversification.

Cellular automata (CA) are excellent models for studying these properties as they are simple to describe yet exhibit phenomena like self-reproduction and autopoiesis. Such models have already shown that it is possible to create patterns with some of the necessary properties for an individual [Hamon et al., 2024]. Therefore, the next important challenge in artificial life is to design systems displaying emergent open-ended evolution (unbounded growth of complexity through an evolutionary process). A process like natural evolution can be called emergent as no final objective is set by the experimenter. Such a process would allow the emergence and complexification of individuals throughout a single simulation without an explicit fitness function.

The submitted video displays the results obtained from modifications of the Flow-Lenia system, aimed at achieving emergent open-ended evolution. The modified system shows the emergent evolution of larger, more complex, and more diverse patterns than those in the original model. We believe this is an important step toward achieving the open-ended emergent evolution of virtual creatures.

2 What: Mass conservative CA with parameter localization

The model presented in this submission is a variation on Flow-Lenia, a class of CA developed by Plantec et al., 2023, which extends the Lenia system. The Lenia system refers to a family of continuous CA introduced by Chan, 2018. Flow-Lenia uses the same building blocks as Lenia but interprets the values of the cells as mass density. Instead of directly adding values to each cell based on a potential map computed from the previous state, we make the matter flow inside the grid by following the gradients of the potential map. This mechanism ensure mass conservation throughout the simulation.

By considering a flow of matter, the Flow-Lenia formulation allows any information, such as update rule parameters, to be attached to the moving matter, making them dynamic and localized. Thanks to this idea, multiple update parameter sets can now share the same grid. Crucially, when parameters move to a new cell, they can be altered using random variations and combinations with other cell parameters. These selection and mixing rules greatly influence the types and diversity of patterns that can emerge. Within a single run of the simulation, new patterns emerge, spread, and sometimes disappear. The mass conservation property introduces competition for matter, which may be a useful property for triggering an emergent evolutionary process.

While the general framework is similar to that of Plantec et al., 2023, the size and complexity of the patterns observed in the video were greatly improved by modifying the parameter mixing rules to allow for better coexistence and interaction of matter with different cell parameters. Modifications to the environment, such as enclosing walls to help create ecological niches, were also considered.

References

Chan, B. W.-C. (2018). Lenia-biology of artificial life. *arXiv preprint arXiv:1812.05433*.

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Plantec, E., Hamon, G., Etcheverry, M., Oudeyer, P.-Y., Moulin-Frier, C., & Chan, B. W.-C. (2023). Flow-lenia: Towards open-ended evolution in cellular automata through mass conservation and parameter localization. *Artificial Life Conference Proceedings 35*, *2023*(1), 131.