Selecting Continuous Life-Like Cellular Automata for Halting Unpredictability: Evolving Abiogenesis

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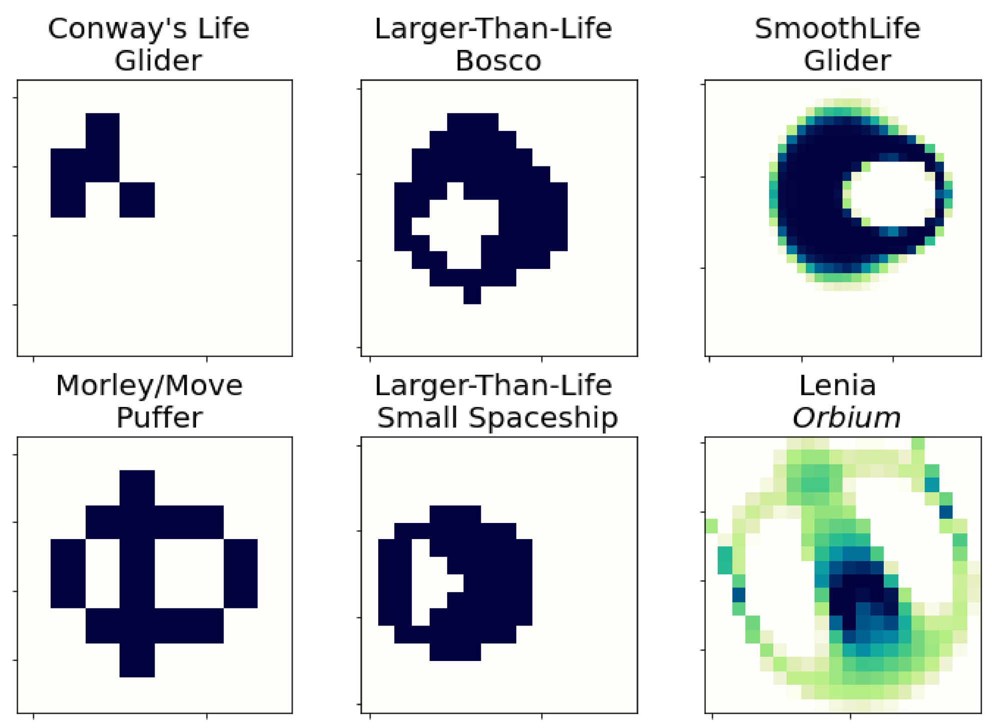

Figure 1: Gliders in cellular automata. Clockwise from top left: reflex glider from Conways Life[1], 'Bosco' pattern from Larger than Life (LtL) [4], SmoothLife glider [6], puffer pattern in Morley (Life-like CA), small spaceship from LtL [4], Orbium from Lenia [2]

Conclusions

- In Von Neumann's 29-state cellular automaton (CA) [5], it seemed that life-like properties (*e.g.* replication) requires careful design.
- John H. Conway showed that in fact very simple systems can give rise to life-like behavior [1], and described unpredictability and the ability to disappear or grow without bound as a heuristic for universality.
- Even without selecting for unpredictability, CA that have both the capacity for vanishing and for growing patterns frequently support gliders. We show evolved glider patterns from several evolved continuous CA.

Summary

As model systems for self-organization, individuation, and computation, the development and discovery of gliders (mobile patterns, see Figure 1) in CA has garnered substantial interest and effort over the years. John Conway showed that gliders can appear in remarkably simple systems like his Game of Life. (Life rules are B3/S23, which indicates that cells with 3 neighbors take on a value of 1, cells with 2 neighbors retain their current state, and all other cells go to 0 at each time step.) More complicated CA based on Life were subsequently developed, and recently continuously-valued CA, particularly Lenia [2], have attracted strong interest.

In this work we evolved CA based on a variant of the Lenia framework (called Glaberish [3]) to be hard to predict whether all cells in a given grid state will go to 0 or not (Figure 3). In a second step of evolution (Figure 4), we found that within these evolved CA universes we could evolve glider patterns. In fact, CA simply evolved for the simultaneous ability to support vanishing or persistent patterns also readily support glider evolution. Figure 2 shows examples of several evolved glider patterns.

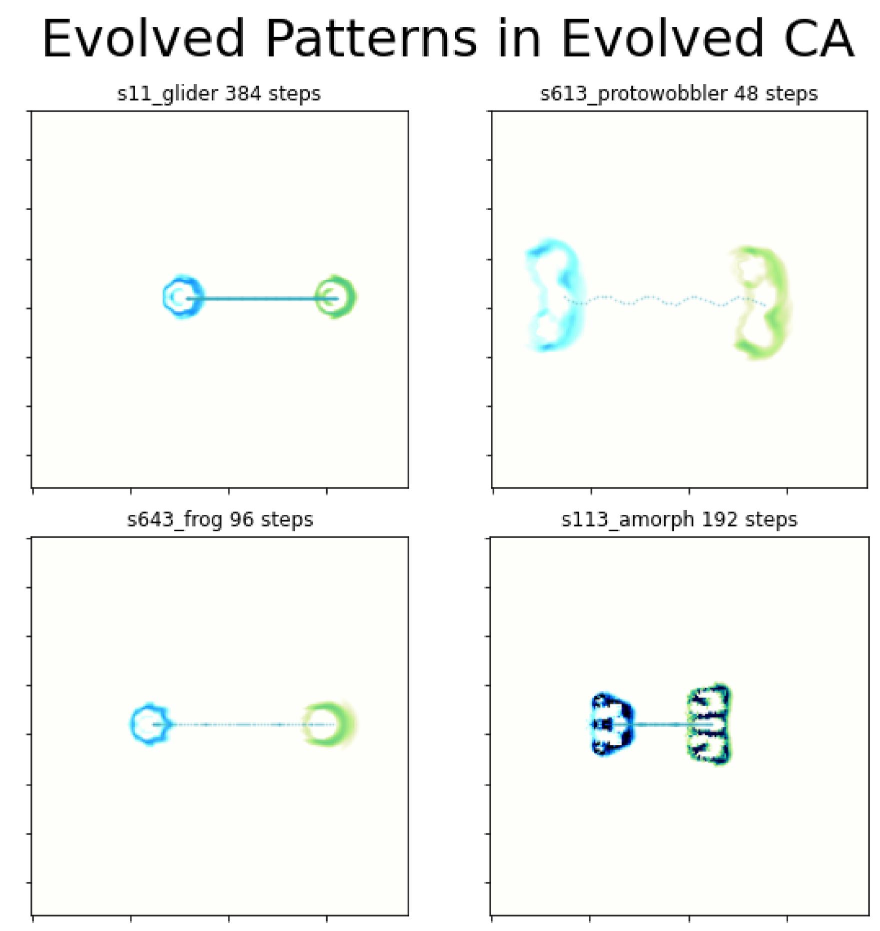

Figure 2: Evolved glider pattern trajectories in evolved CA.

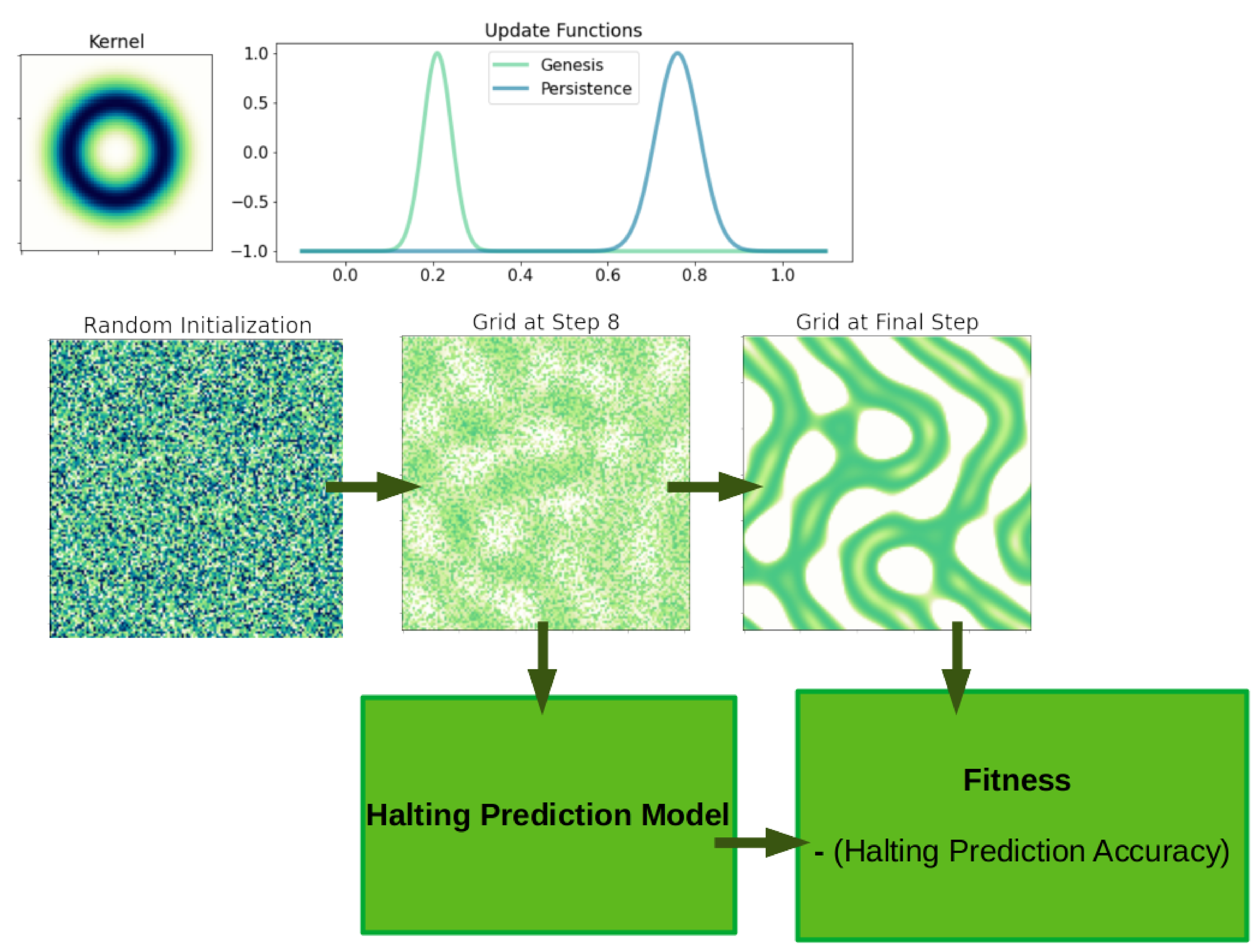

Figure 3: Halting unpredictability evolution.

- Additional information, including animations, for this and related work is consolidated at `https://rivesunder.github.io/yuca/`
- Code for evolving continuous CA is made available under an MIT License at `https://github.com/rivesunder/yuca`
- ArXiv pre-print describing this work at `https://arxiv.org/abs/2204.07541`

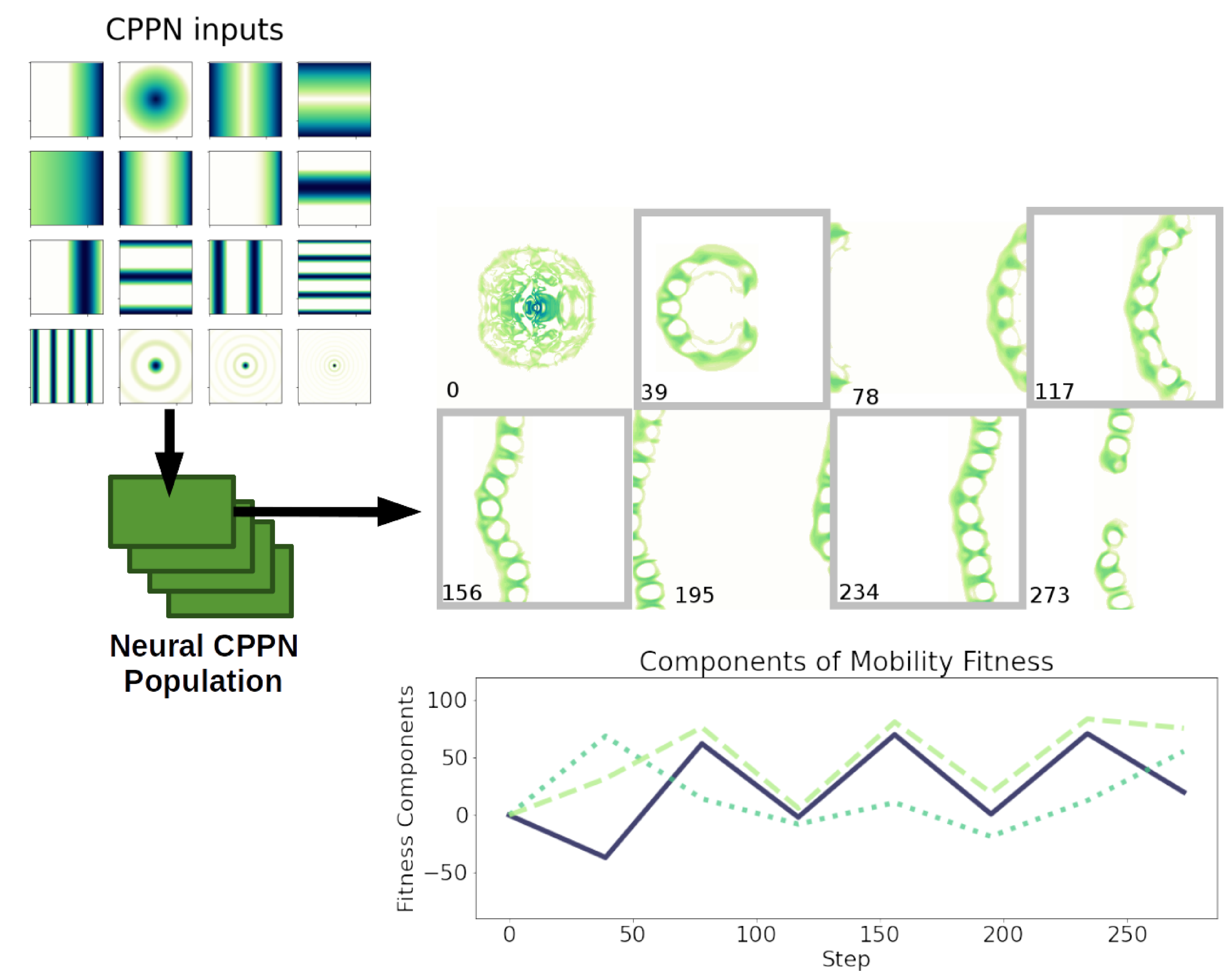

Figure 4: Pattern evolution with mobility-based fitness. Solid line is fitness, dashed line is the motility component, and dotted line is the homeostasis component.

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References

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