Review of: "Self-Replication, Spontaneous Mutations, and Exponential Genetic Drift in Neural Cellular Automata"

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Potential competing interests: No potential competing interests to declare.

This study proposes using Neural Cellular Automata (NCA) to generate patterns that exhibit self-replication with spontaneous, inheritable mutations and exponential genetic drift. It is an effort to model closed worlds with unchanging rules and to approach Open-Ended Evolution. According to the authors, each NCA represents a world with rules almost equivalent to the laws of physics of that world and focuses on the issue of self-replication, diversity of organisms, and evolution. The authors present the results of several experiments to validate the proposed NCA model.

The work is interesting, the use of the English language is satisfactory, and the references show good knowledge of NCA and Open-Ended Evolution.

Nevertheless, some issues need further to be clarified:

1. Page 1, column right, paragraph 1: The authors claim that “Cellular Automata are programs that run..”. In fact, CA are an elegant computing model which dates back to John von Neumann, [1]. The local rules of CA define an emulation of actual macroscopical behaviour.

[1] J. von Neumann and A.W. Burks, “Theory of Self-reproducing Automata”, University of Illinois Press, Urbana, 1996.

2. Page 2, column left, paragraph 1: “…are even used to formally define Unbounded Innovation and Unbounded Evolution.” The authors could add a reference for the definition of the terms of Unbounded Innovation and Unbounded Evolution.

3. Page 2, column right, paragraph 1: The authors could explain the acronym “RGBA”.

4. Page 2, column right, paragraph 1: According to the authors, 1 training step = 96 time steps. How is this value determined? Why 96 and not for example 116?

5. Page 2, column right, paragraph 1: According to the authors, the maximum number of training steps is determined ad hoc by judging loss convergence. The authors could further clarify whether a cut-off (truncate) value exists. Who is the one that judges? Is the training process, not an automated procedure?

6. Page 2, column right, paragraph 1: The authors could add a reference to the term “gradient descent”.

7. Page 2, column right, paragraph 2: The authors have modified the training procedure of the NCA for some of the

experiments. Thus, the authors are kindly requested to explain the reason for the “target alteration”.

8. Page 3, column left, paragraph 1: What do the remaining 12 values represent? Is there a physical correspondence?

9. Page 3, column left, paragraph 3: According to the authors, “our definition of genetic drift is different from the biological definition.” The authors could provide more details to make this difference more straightforward or could add a reference.

10. Figure 4, caption (a): The caption could be rephrased to become more understandable.

11. Page 4, column left, paragraph 1: “close to the target image, as shown in .” Missing information (shown in ?).

12. The Conclusion section is missing.

13. A general comment is that a mathematical approach to the model and its operation is missing from the text. The authors could have reached more precision when describing the model if they had included mathematical formulas within the manuscript, primarily when they referred to the fundamentals of the applied NCA, e.g. the rules.

14. The authors could enrich their literature review by adding more references that combine cellular automata applications and genetic procedures. For example:

[1] Georgoudas I G, Sirakoulis G C, Scordilis E, Andreadis I. Parametric optimisation in a 2-D cellular automata model of fundamental seismic attributes with the use of genetic algorithms In: Advances in Engineering Software, vol. 42, no. 9, pp. 623–633, 2011.

[2] Chatziagorakis P, Sirakoulis G Ch, Lygouras J. N. Design automation of cellular neural networks for data fusion applications In: Microprocessors and Microsystems, vol. 36, no. 1, pp. 33–44, 2011.

[3] Chatziagorakis P, Sirakoulis G C, Lygouras J. Automatic generation of cellular neural networks for distributed sensor data processing In: 2009 13th Panhellenic Conference on Informatics, pp. 35–39, IEEE 2009.

The paper is interesting but it needs to address the comments above to be regarded as publishable.