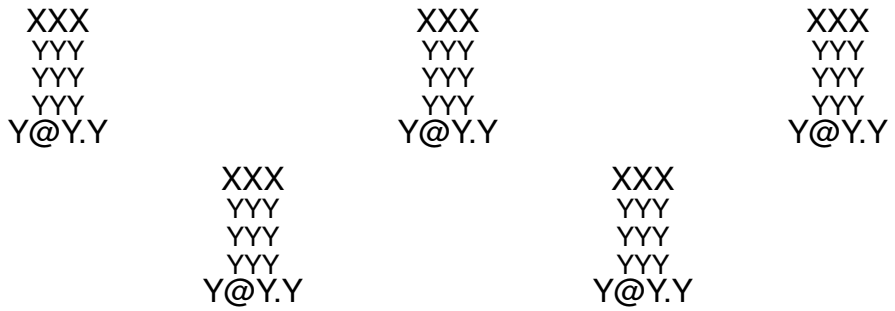
Heterogeneous Cellular Automata Evolution in a Fluctuating Environment



ABSTRACT

The importance of environnemental fluctuations in the evolution of living beings by natural selection have been widely noted by biologists and have been linked to many important characteristics of the life as: modularity, plasticity, size of the genotype, mutation rate, learning or epigenetic adaptations. However, in artificial life simulations, environmental fluctuations are usually seen as a problem to be solved rather than an essential characteristic of evolution. We propose in this paper to use HetCA, an heterogeneous cellular automata characterized by its ability to generate open ended long-term evolution and evolutionary progress, to measure the impact of different forms of environmental fluctuations. Our results indicate that environnemental fluctuations induce mechanisms analogous to epigenetic adaptations in HetCA.

CCS Concepts

•**Computer systems organization** → **Embedded systems;** *Redundancy;* Robotics; •**Networks** → Network reliability;

Keywords

Cellular automata; environnemental fluctuations; Open-Ended Evolution; Epigenetic; Evolvability

1. INTRODUCTION

If early population genetics theory assumed the environment to be constant, since Richards Levins works [4] in the 70 up to Evolution in Four Dimensions by Eva Jablonka and al. [1] the importance of environnemental fluctuations in the evolution of living beings by natural selection have been widely noted. Through those works and others, environmental fluctuations have been linked to many important questions about the mechanisms of evolution such as: modularity, plasticity, size of the genotype, mutation rate and through this the evolvability. Recently Jablonka[1] have developed the idea that epigenetic mechanisms controlling the rate of changes in certain genes have evolved to counter frequent environmental changes. Environmental changes can include introduction of new predator or new potencial food, radical environment modifications such as climate change inducing environmental stress but also cyclic changes such as daily cycle of light and darkness, seasons...

In [3] Lachemann model the consequences of such cycling variations on phenotypical inheritances. Their model predict that, when those cycles are longer than the reproductive cycle but relatively short heritable variations produced by non-DNA inheritance systems are likely to be observed.

Many work in artificial life approach the issue of environmental variations, but the greater part are interested mainly in the spacial variations, or considering them as a problem to solve.

This paper is organized as follows. Section 2 highlights consequences of variable environment in biological evolution. In Section 3, we explain the mecanisms of HetCA simulation. The implementation of environmental fluctuation in HetCA is then explained in Section 4. Section 5 details the computer experimental setup while we reports experimental results in Section 6. We discuss the implications of these results in Section 7. Finally, Section 8 concludes the paper.

2. BACKGROUND

In [5] Lipson demonstrated a correlation between the modularity and the rate of change of the environment resources. While in [6] Yu used observed populations exploit neutrality to cope with environmental fluctuations and therefore evolve some sort of evolvability under 2 alternating objective functions. Both simulations used Genetic Programming (GP) and fitness explicit functions.

3. HETCA

The eukaryotic chromatin remodeling machinery, the cell

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cycle regulation systems [2], the nuclear envelope, the cytoskeleton, and the programmed cell death (PCD, or apoptosis) apparatus all are such major eukaryotic innovations, which do not appear to have direct prokaryotic predecessors.

4. EXPERIMENTAL SETUP

5. RESULTS

6. DISCUSSIONS

7. CONCLUSIONS

8. REFERENCES

[1] Eva Jablonka, Marion J Lamb, and Anna Zeligowski. *Evolution in Four Dimensions, revised edition: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life*. MIT press, 2014.

[2] EV Koonin and L Aravind. Origin and evolution of eukaryotic apoptosis: the bacterial connection. *Cell death and differentiation*, 9(4):394–404, 2002.

[3] Michael Lachmann and Eva Jablonka. The inheritance of phenotypes: an adaptation to fluctuating environments. *Journal of theoretical biology*, 181(1):1–9, 1996.

[4] Richard Levins. *Evolution in changing environments: some theoretical explorations*. Number 2. Princeton University Press, 1968.

[5] Hod Lipson, Jordan B Pollack, and Nam P Suh. On the origin of modular variation. *Evolution*, 56(8):1549–1556, 2002.

[6] Tina Yu. Program evolvability under environmental variations and neutrality. In *Proceedings of the 9th annual conference companion on Genetic and evolutionary computation*, pages 2973–2978. ACM, 2007.