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Digital Evolution for Ecology Research: A Review

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Abstract- In digital evolution, populations of computational organisms evolve via the same principles that govern natural selection in nature. These platforms have been used effectively as a controlled system to conduct evolutionary experiments and develop novel evolutionary theories. In addition to their complex evolutionary dynamics, many digital evolution systems produce rich ecological communities. As a result, digital evolution is also a powerful tool for research on eco-evolutionary dynamics. Here, we review the current research in which digital evolution platforms have been used to address eco-evolutionary (and in some cases purely ecological) questions. This work has spanned various topics, including competition, facilitation, parasitism, predation, and macro-ecological scaling laws. We argue for the value of further ecological research in digital evolution systems and present some promising directions for further research.

Keywords- Digital evolution, Eco-evolutionary dynamics, Ecological interactions, Evolutionary computation

INTRODUCTION

Over the past decade, researchers have become increasingly aware of ecological and evolutionary dynamics' profound impact on each other (Schoener, 2011; Hendry, 2016). Ecological interactions shape the underlying fitness landscape that is traversed by evolving populations. At the same time, evolutionary forces continually adjust the composition of organisms that make up that ecosystem. As such, ever-shifting fitness landscapes and fluctuating ecosystems continually fuel each other's change. However, in a digital system, mutation can be turned off with the flip of a switch (ecology mode), as can interactions among organisms (evolution mode). Another obstacle to understanding eco-evolutionary dynamics is that evolution experiments require thousands of generations. Even for rapidly reproducing organisms like bacteria, it takes nearly a year to reach 2000 generations (Wiser et al., 2013). Still, most digital evolution systems can reach this milestone in less than an hour. Similarly, collecting ecological data at a resolution that is high enough to answer many questions is labour-intensive in biological systems, but it can be automated in its digital counterparts. The speed and pellucidity of digital systems enable us to test our intuition in near real-time, allowing us to form precise questions before investing the time to conduct a well-targeted laboratory experiment.

DIGITAL EVOLUTION SYSTEMS THAT SUPPORT ECOLOGICAL RESEARCH

Most digital evolution platforms have the capacity to support ecological research, but each has its strengths and weaknesses. Just as it is advantageous for a community of researchers to use a range of model systems in the laboratory and field, it is also advantageous to use a range of digital platforms. The representation of individuals varies dramatically from platform to platform, making each a distinct substrate for evolution to act on. Every substrate—including biology on earth has its quirks. Thus, truly understanding the behaviour of a specific system requires studying that system specifically. However, observing the same behaviour across multiple distinct substrates provides strong evidence that a result generalizes.

CONSIDERATIONS FOR STUDYING ECOLOGY WITH DIGITAL EVOLUTION

Digital evolution is a powerful tool for studying ecology. Nevertheless, there are a few challenges that it is important to be aware of when applying it: 1. Competition for Space 2- Choosing the Right Level of Complexity.

ECOLOGY'S ROLE IN THE EVOLUTION OF COMPLEXITY

There is increasing evidence from both evolutionary computation and more traditional digital evolution to suggest that ecology plays an important role in the evolution of complexity (Walker and Ofria, 2012; Dolson et al., 2018a). As has been clear since the early days of evolutionary computation, mutation, inheritance, and selection alone are insufficient to generate solutions to complex problems (Goldberg et al., 1987); additional dynamics and properties are necessary. Mostly, the dynamics that have helped achieve this goal have been ecological (Dolson et al., 2018b). However, it is still unclear whether ecological dynamics are necessary for the evolution of complexity and, if so, which ecological dynamics are in particular. Digital evolution has previously proven to be a powerful tool for understanding the evolution of complexity (Lenski et al., 2003). It has also been a powerful tool for untangling ecology from evolution via experiments in which mutations and ecological interactions are turned on and off (Zaman et al., 2011). Thus, it seems an ideal platform for untangling questions at the intersection of ecology and the evolution of complexity.

CONCLUSIONS

Digital evolution is the most important role play in modern science. The present era is digital. Digitization has played a major role in India becoming a developed country. Digital technology has played a major role in ecology's development, modern activities, and related branches. Digital evolution offers a rich environment for asking ecological questions, particularly as they intersect with evolutionary questions. We have summarized a number of promising software systems to use for this purpose and reviewed ecologically relevant research carried out to date using them. While much of the research thus far has centred on eco-evolutionary dynamics, we believe that digital evolution platforms also have potential as a platform for studying more traditional ecology questions. To aid in such research and further research into eco-evolutionary dynamics, we have spelt out some suggestions for how best to study ecology in a digital evolution system. Lastly, we have provided suggestions for future research directions. We hope this review will assist and encourage others to take advantage of digital

evolution's powerful toolset. The need of the hour is for digital technology and computers to become essential parts of ecology's all-around development and all the related branches. Computers and digitization have become vital to science or biology's development and transparency. Using these instruments to bring accuracy and quality to research work has become necessary in modern times.

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